Prime Item Development Specification: Combustion Integrated Rack

Fluids and Combustion Facility

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Final
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AUTHORIZED by CM when under FORMAL Configuration Control	
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Prime Item Development Specification for the Fluids and Combustion Facility Combustion Integrated Rack

Configuration Item No.: 67212MFAH10000
Contract No.: NAS3-99155
CDRL Sequence No.: Not Applicable

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PREFACE

The National Aeronautics and Space Administration is developing a modular, multi-user experimentation facility for conducting fluid science and combustion science experiments in the microgravity environment of the International Space Station (ISS). This facility, called the Fluids and Combustion Facility (FCF), consists of three test platforms: the Fluids Integrated Rack (FIR), the Combustion Integrated Rack (CIR), and the Shared Accommodations Rack (SAR). This document defines the requirements for the CIR and is the source for CIR technical and verification requirements.

This specification was prepared as a Type B1 Prime Item Development Specification, Form 1b, as defined in NASA document SSP 41171. It defines the CIR development item, applicable documents, characteristics that the CIR must exhibit, design and construction requirements, computer resource requirements, logistics requirements, personnel and training requirements, and characteristics of any subordinate elements. This document also discusses quality assurance provisions, preparation for shipping, and notes.

**PRIME ITEM DEVELOPMENT SPECIFICATION:
FLUIDS AND COMBUSTION FACILITY
COMBUSTION INTEGRATED RACK (CIR)**

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REVISION PAGE
CIR PRIME ITEM DEVELOPMENT SPECIFICATION

Revision	Date	Description of Change or ECO's Incorporated	Verification and Date
Draft	2/10/99	Initial Draft for MRDOC RFP	
Draft	07/14/00	Initial	
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1.0 SCOPE

This specification establishes the performance, design, development, and qualification requirements for the Combustion Integrated Rack (CIR) in both its launch configuration and its on orbit configuration. The CIR is part of the United States Laboratory Module (US Lab) Fluids and Combustion Facility (FCF) of the International Space Station (ISS). This specification is prepared per the format as specified in SSP 41171. The CIR for the Ground Integration Unit, Engineering Development Unit and the Payload Training Center Unit, are covered in the Ground Segment Specification, FCF-SPEC-0005.

1.1 Identification.

This specification covers the CIR configuration item 67212MFAH10000.

1.2 Classification.

No type, grade, class, or other similar designation is applicable at this time.

1.3 International standardization agreement code.

International standardization agreement code numbers are not applicable to the configuration item defined by this specification.

1.4 Assembly overview.

The CIR is part of a modular, multi-user facility whose primary purpose is to perform sustained, systematic research in the discipline of combustion science. The CIR is the first FCF segment to be installed as a permanent facility within the US Lab.

1.5 TBD’s and Exceptions.

Approved exceptions to the requirements of this specification are provided in Appendix G. TBD’s are given in Appendix H.

2.0 APPLICABLE DOCUMENTS

This section discusses all documents, including both government and nongovernment documents, applicable to this specification.

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks.

2.1.1.1 Federal specifications.

Not applicable.

2.1.1.2 Military specifications.

MIL-C-38999	Connector, Electrical, Circular, Miniature, High Density Quick Disconnect, (Bayonet, Threaded, and Breech Coupling), Environmental Resisting, Removable Crimp and Hermitic Solder Contacts, General Specification for
MIL-C-5015	Connectors, Electrical, Circular Threaded, An Type, General Specification for
MIL-C-81569	Connectors, Electrical Rectangular, Crimp Contact, General Specification for
MIL-C-83733	Connectors, Electrical Miniature, Rectangular Type, Rack to Panel, Environmental Resisting, 200° F Total Continuous Operating Temperature, General Specification for

2.1.1.3 Federal standards.

FED-STD-595	Federal Standard Colors Used in Government Procurement

2.1.1.4 Federal information processing standards.

Not applicable.

2.1.1.5 Military standards.

MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) Document
MIL-STD-1553B	Digital Time Division Command/Response Multiplex Data Bus Handbook

2.1.1.6 Military handbooks.

MIL-HDBK-1553	Digital Time Division Command/Response Multiplex Data Bus Handbook

(Copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents order desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.1.2 Other government documents, drawings, and publications.

The following other government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the exact issue shown applies to this specification.

2.1.2.1 Other government documents.

FCF-PLN-0036	Material and Processes Control Plan
FCF-DOC-002	Science Requirements Envelope Document – Fluids and Combustion Facility
FCF-DOC-004	Compliance Matrix, Science Requirements Envelope Document – Fluids and Combustion Facility
FCF-IDD-CIR	Combustion Integrated Rack Interface Definition Document
FCF-SPC-0001	Systems Specification – International Space Station Fluids and Combustion Facility
JSC 27199	End Item Specification for the International Space Station Portable Utility Light
CIR-PLN-0056	Combustion Integrated Rack Verification Plan
JSC 27260	Decal Process Document and Catalog
JSC, MA2-95-048	NASA IVA Touch Temperature Safety interpretation letter
MSFC-STD-275	Marking of Electrical Ground Support Equipment, Front Panels, and Rack Title Plates
MSFC-SPEC-250	Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specification for Document
NASA-STD-5003	Fracture Control Requirements for Payloads Using the Space shuttle
NHB 5300.4(1B)	Quality Program Provisions for Aeronautical and Space System Contractors
NHB 6000.1	Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems, Equipment, and Associated Components
NSTS 1700.7	Safety Policy and Requirements for Payloads Using the

ISS Addendum	International Space Station
NSTS 13830	Implementation Procedure for NSTS Payloads System Safety Requirements
NSTS 18798	Interpretations of National Space Transportation System (NSTS) Payload Safety Requirements
SAMS-FF-DOC-101	SAMS-FF Triaxial Sensor Head Interface Document
SN-C-0005	NSTS Contamination Control Requirements Manual
SSP 30237	Space Station Requirements for Electromagnetic Emissions and Susceptibility Requirements
SSP 30238	Space Station Electromagnetic Techniques
SSP 30240	Space Station Grounding Requirements
SSP 30242	Space Station Cable/Wire Design and Control Requirements for Electromagnetic Compatibility
SSP 30243	Space Station Requirements for Electromagnetic Compatibility
SSP 30245	Space Station Electrical Bonding Requirements
SSP 30257:004	Space Station Program Intravehicular Activity (IVA) Restraints and Mobile Aid Standard Interface Control Document (ICD)
SSP 30262:013	Smoke Detector Assembly Standard ICD
SSP 30312	Electrical, Electronic, and Electromechanical Parts Management and Implementation Plan for Space Station Program
SSP 30423	Space Station Approved Electrical, Electronic, and Electromechanical Parts List
SSP 30426	External Contamination Control Requirements
SSP 30512	Ionizing Radiation Design Environment
SSP 30573	Space Station Program Fluid Procurement and Use Control Specification
SSP 41171	Preparation of Program-Unique Specifications – International Space Station Program
SSP 41002	International Standard Payload Rack to NASA/NASDA Modules Interface Control Document
SSP 41017	Rack to Mini Pressurized Logistics Module ICD Part 1 and Part 2
SSP 41175-2	Software ICD Part 1 Station Management and Control to ISS Book 2 General Interface Software Interfaces Requirement
SSP 50005	International Space Station Flight Crew Integration Standard (NASA-STD-3000/T) Document
SSP 50184	High Rate Data Link Physical Media, Physical Signaling and Protocol Specifications
SSP 50313	Display and Graphical Commonality Standard
SSP 52005	ISS Payload Flight Equipment and Guidelines for Safety Critical Structures
SSP 52050	Software Interface Control Document Part 1, International Standard Payload Rack to International Space Station
SSP 57000	Pressurized Payloads Interface Requirements Document
SSP 57001	Pressurized Payload Hardware ICD
SSP 57002	Pressurized Payload Software ICD

SSP 57007	ISPR Structural Integrator's Handbook
SSP 57010	Pressurized Payloads Generic Payload Verification Plan
SSP 57011	Payload Verification Plan
SSP 57020	Pressurized Payload Accommodations Handbook
SSP 57217	FCFCIR Hardware ICD
SSQ 21635	Connectors and Accessories, Electrical, Rectangular, Rack and Panel
SSQ 21654	Cable, Single Fiber, Multitude, Space Quality, General Specification for Document
SSQ 21655	Cable, Electrical, MIL-STD-1553B Data Bus, Space Quality, General Specification for Document

2.1.2.2 Drawings.

Not applicable.

2.1.2.3 Publications.

Not applicable.

2.2 Nongovernment documents.

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of a conflict between the documents referenced herein and the content of this specification, the content of this specification shall be considered a superseding requirement.

2.2.1 Specifications.

2.2.2 Standards.

ISO/IEC 8802-3	Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specification

2.2.3 Other publications.

220G07455	Rack Handling Adapters – Upper Structure
220G07470	Rack Handling Adapters – Lower Structure
220G07475	Rack Handling Adapters - KSC Lower Structure
220G07500	Rack Shipping Containers
CCSDS 301.0-B-2	CCSDS Time Code Format
CCSDS 701.0-B-2	Advanced Orbiting Systems, Network and Data Links: Architectural Specification, Blue Book

EIA/TIA RS-250-C	Electrical Performance for Television Relay Facility
D683-10007	Fire Detection Assembly
683-17103	Fluid System Server Interface Definition Drawing
NTC-7	Video Facility Testing Technical Performance Objectives (NTC)
D684-10056-01	International Space Station, Prime Contractor Software Standards and Procedures Specification

2.3 Order of precedence for documents.

In the event of a conflict between this document and other documents referenced herein, the requirements of this document shall apply. In the event of a conflict between this document and the contract, the contractual requirements shall take precedence over this document. All documents used, applicable or referenced, are to be the issues defined in the Configuration Management (CM) contract baseline. All document changes, issued after baseline establishment, shall be reviewed for impact on scope of work. If a change to an applicable document is determined to be effective, and contractually approved for implementation, the revision status will be updated in the CM contract baseline. The contract revision status of all applicable documents is available by accessing the CM database. Nothing in this document supersedes applicable laws and regulations unless a specific exemption has been obtained.

3.0 REQUIREMENTS

The requirements that form this document are found in FCF-DOC-002 in association with FCF-DOC-004, FCF-SPC-0001, and SSP 57000 as listed in the Dynamic Object Oriented Requirements System (DOORS) program.

3.1 CIR definition.

3.1.1 CIR description.

The CIR can either be in a launch configuration or an on orbit configuration. It is packaged in a program furnished International Standard Payload Rack (ISPR). In the launch configuration, the CIR is placed in a Multi-Purpose Logistics Module (MPLM) along with associated stowage items that will make up the CIR on orbit configuration. Once the CIR is installed in the US Lab, astronauts will complete the assembly to the CIR on orbit configuration. Figure 1 and Figure 2 show the launch and on orbit CIR configurations. (Note: In the actual launch configuration, the Optics Bench will not be deployed and the rack doors will be closed.) In conjunction with Principal Investigator (PI) hardware and software, the CIR will perform sustained, systematic research in combustion science. Most of the requirements derived from FCF-DOC-002 cannot be met or verified without PI or PI-simulated hardware and/or software.

3.1.2 CIR mission.

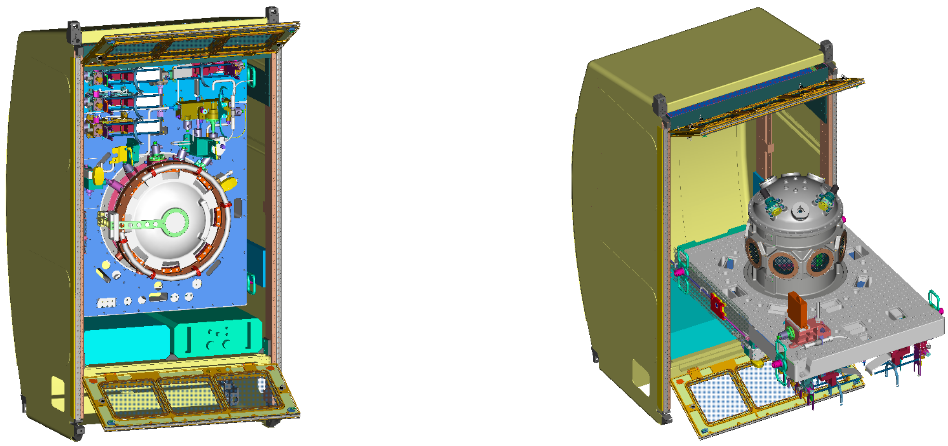
The CIR mission is to perform microgravity experiments in combustion science over the life of the FCF. The expected life of the CIR is twelve to seventeen years.

3.1.3 Threat environment.

Not applicable.

3.1.4 CIR functional schematic.

The CIR is nonoperational in its launch configuration. Figure 3 shows the functions of the CIR. The CIR will be designed to allow investigation in combustion science using gaseous, liquid, and solid fuels at various pressures and oxygen concentrations to better understand the combustion processes. The microgravity environment allows for measurement and observation of combustion processes that cannot be made in sustained gravity. The modular design of the CIR assemblies allows for flexibility in configuring for specific experiments and easy maintainability of the hardware.

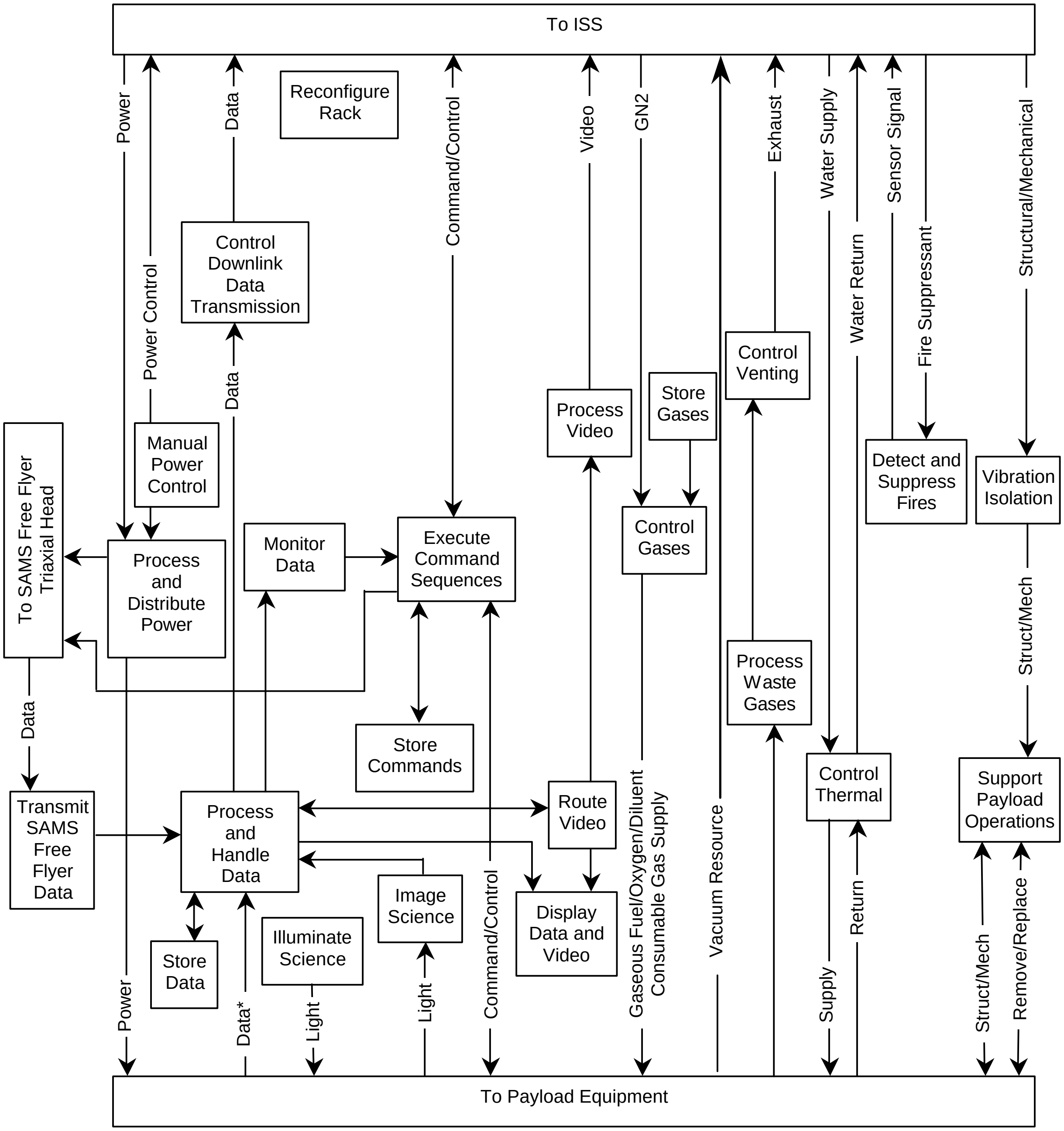


Optic bench front view **Optic bench rear view**

Figure 1. CIR launch configuration

Optic bench front view **Optic bench rear view**

Figure 2. CIR on orbit configuration



* - including analog & digital video

Figure 3. CIR functional schematic

3.1.5 Interfaces.

3.1.5.1 External interfaces.

The external interfaces for the CIR in the launch configuration are the physical attachments of the CIR to the MPLM and are defined in SSP 41017. All assemblies not mounted in the rack will be in stowage containers. Figure 4 shows the external and experiment interfaces of the CIR to the US Lab. SSP 57007 gives the physical interfaces for the CIR to the US Lab and MPLM. Table I lists the electrical/data interfaces to the US Lab. Table II gives the fluids interfaces connecting the CIR to the US Lab.

The CIR to SAR interfaces consist of communication links between the two racks that provide for the transfer of data and commands. These interfaces allow the SAR to coordinate operations of all the racks and provide support to the CIR. The high-speed image data interface will be a single fiber optic cable containing several cable fibers. This interface transfers raw image data. The other data interfaces will be incorporated into another fiber optic cable containing several cable fibers. The data protocols across this interface are Ethernet, analog video, Common Area Network (CAN) bus and synchronization bus, which provides timing synchronization between racks. Each cable rack connection is an adapter, part no. MTP-ADPT connected to a MTFA-12M5 ferule inside a MTP-012M-SM housing.

Table I. Electrical/data interfaces between CIR and US Lab

Interface	Module Connector	Part Number
Main Power	J1	NATC07T25LN3SN
Essential/Auxiliary Power	J1	NATC07T25LN3SA
1553 Bus A	J3	NATC07T15N35SN
1553 Bus B	J4	NATC07T15N35SA
HDRL	J7	NATC07T13N4SN
Optical Video	J16	NATC07T15N97SB
Fire Detection System/Power Maintenance	J43	NATC07T13N35SA
LAN-1	J46	NATC07T11N35SB
LAN-2	J47	NATC07T11N35SB

Table II. Fluids interfaces used to connect the CIR to the US Lab

Interface	Part Number
Thermal Control System (TCS) Moderate Supply	683-16348, male, Category 6, Keying B
TCS Moderate Return	683-16348, male, Category 6, Keying C
Gaseous Nitrogen	683-16348, male, Category 8, Keying B
Vacuum Exhaust	683-16348, male, Category 3, Keying B
Vacuum Resource	683-16348, male, Category 3, Keying A

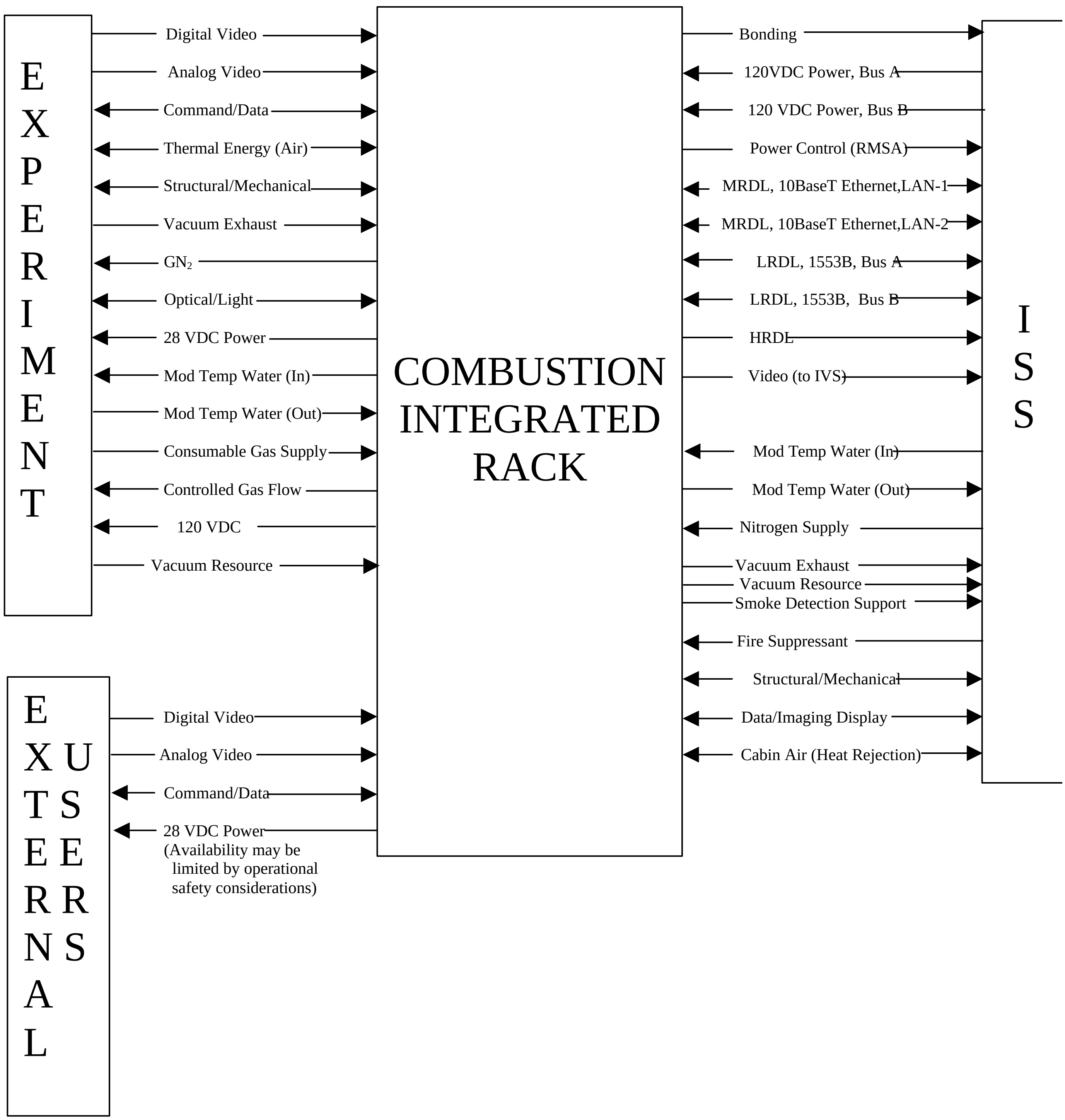


Figure 4. CIR external interface and experiment interface schematic

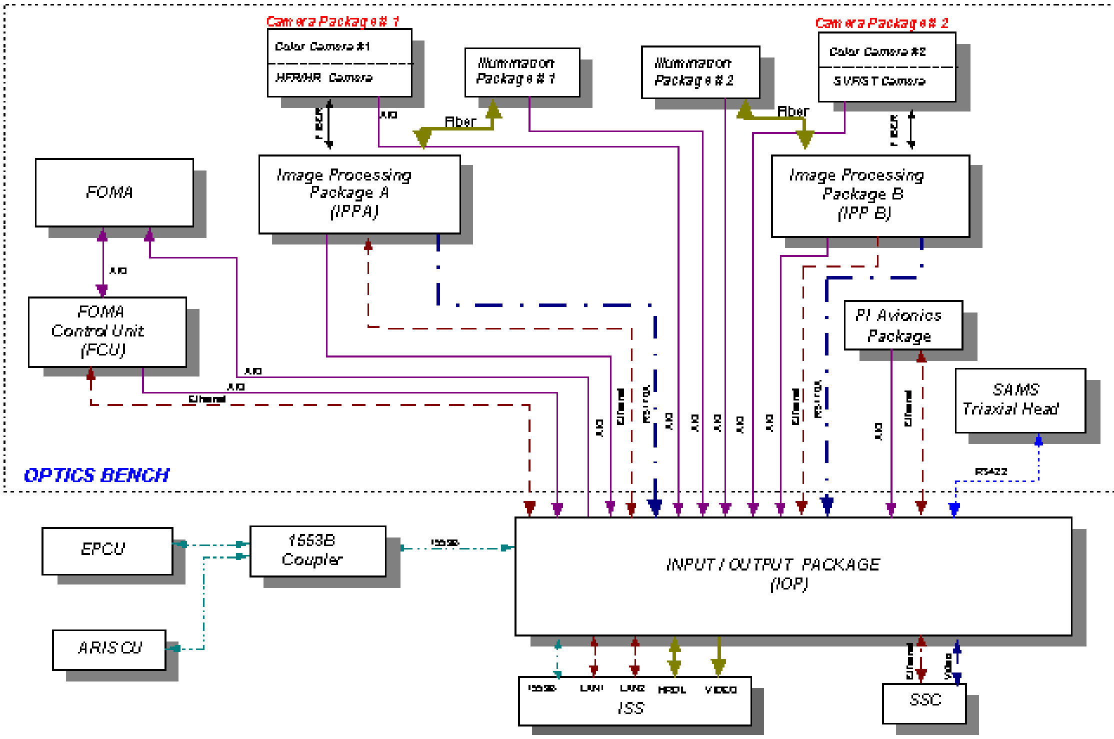


Figure 5. CIR avionics interfaces

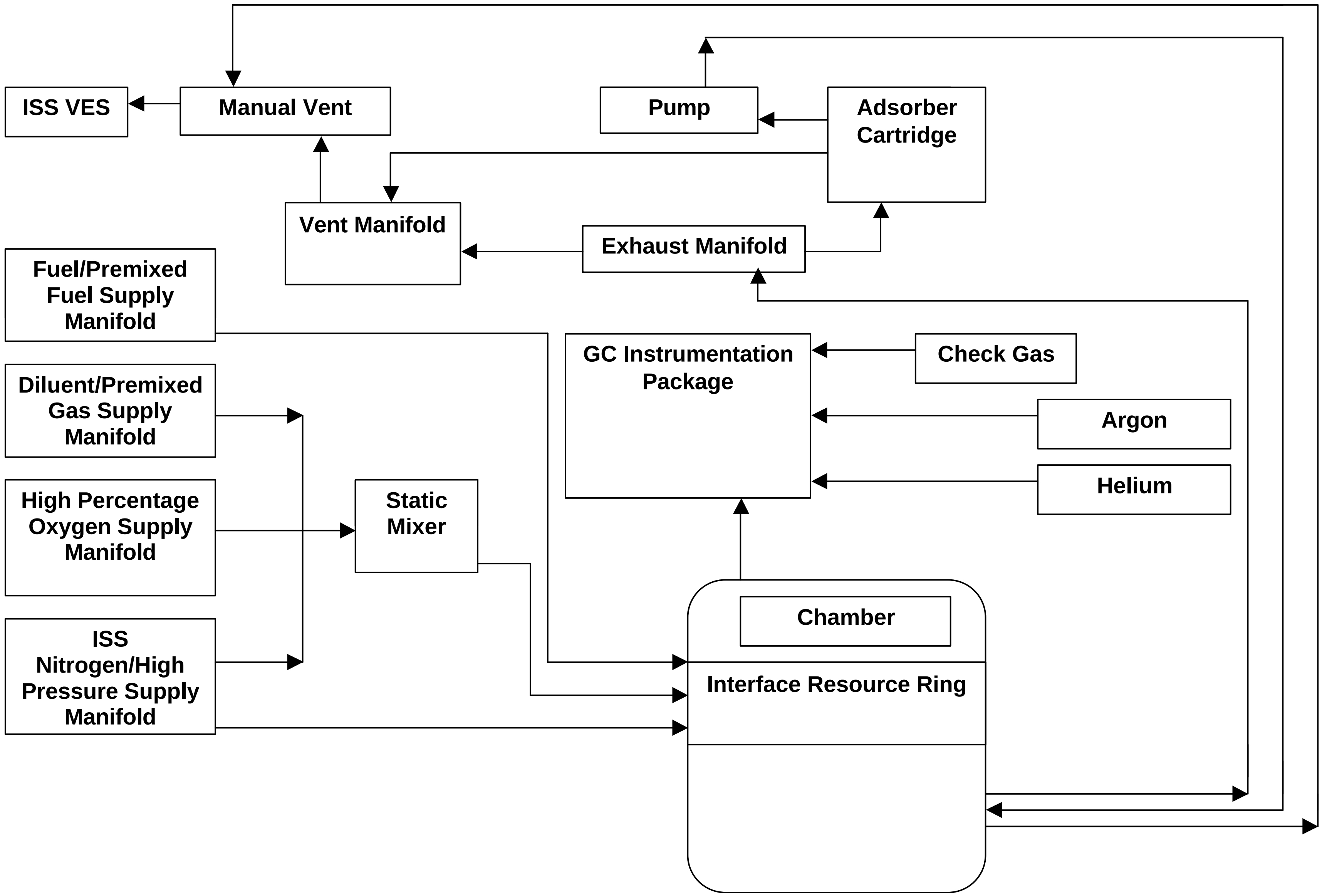


Figure 6. CIR internal functional fluids interfaces

In the event the CIR must be installed into the Columbus Orbital Facility (COF), the CIR will be operated in a degraded condition and will use the interfaces as specified in SSP 57000 for the COF.

3.1.5.2 Internal interfaces.

The internal structural interfaces and assemblies within the CIR are given in Appendix C. The specific interface descriptions are specified in the respective product specifications. Figure 5 gives the avionics interfaces of the internal assemblies within the CIR. Appendix D lists the electrical/data interfaces for PI-specific hardware and assemblies within the CIR. Figure 6 shows the CIR internal functional fluids interfaces. The CIR internal gas interfaces are given in Appendix E. Appendix F lists the internal environmental control system interfaces.

3.1.5.3 Experiment interfaces.

Experiment interfaces are defined in FCF-IDD-CIR.

3.1.5.4 SAMS data interface.

<TBD 03-01>

3.1.6 Major components list.

The below list includes the nongovernment furnished major components that describe the CIR:

1. Image Processing Package (IPP) – 67212MFAN17000
2. Input/Output Package (IOP) – 67211MFAB10000
3. CIR Package Assembly – 67212MFAH10000
4. Optic Bench Assembly – 67212MFAH20000
5. Actuator Pin Assembly –67212MFAH21000
6. Removable Handle Assembly – 67212MFAH40000
7. Combustion Chamber Assembly – 67212MFAH30000
8. Linear Hinged Arm Detent Assembly – 67212MFAH31000
9. Interface Resource Ring Assembly – 67212MFAH32000
10. Window Assemblies – 67212MFAH33000
11. Aft End Cap Assembly – 67212MFAH34000
12. Gas Chromatograph (GC) Assembly – 67212MFAM30000
13. FOMA Control Unit (FCU) Assembly – 67212MFAM40000
14. Vent Manifold Assembly – 67212MFAM20000
15. Exhaust Manifold Assembly – 67212MFAM21000
16. Manual Vent Valve Manifold Assembly – 67212MFAM22000
17. Re-circulation Pump Manifold Assembly – 67212MFAM23000
18. Fuel Manifold Assembly – 67212MFAM10000
19. Diluent Manifold Assembly – 67212MALM12000
20. Static Mixer Assembly – 67212MFAM14000
21. Oxygen Manifold Assembly – 67212MFAM11000

22. Nitrogen/High Pressure Manifold Assembly – 67212MFAM13000
23. Bottle Assemblies – 67212MFAM60000
24. Large Adsorber Cartridge Assembly – 67212MFAM61000
25. Adsorber Cartridge Support Bracket Assembly– 67212MFAM24000
26. Small Adsorber Cartridge Assembly – 67212MFAM62000
27. Optics Bench Slide Assembly – 67212MFAG20000
28. Rack Door Closure – 67211MFAG10000
29. Electrical Power Control Unit (EPCU) Rack Attachment– 67211MFAG40000
30. IOP Rack Attachment– 67211MFAG30000
31. Air Thermal Control Assembly (ATCA) – 67211MFAD10000
32. Water Thermal Control System (WTCS) – 67211MFAD20000
33. Gas Interface Assembly – 67211MFAD30000
34. Fire Detection and Suppression Assembly – 67211MFAD40000
35. Color Camera Assembly – 67212MFAN12000
36. Low Light Level – UV Camera Assembly – 67212MFAN14000
37. Low Light Level – IR Camera Assembly – 67212MFAN15000
38. High Frame Rate (HFR)/High Resolution (HR) Camera Assembly -67212MFAN10000
39. High Bit Depth Multispectral (HiBMs) Camera Assembly – 67212MFAN11000
40. Illumination Package Assembly – 67212MFLAN13000
41. Mid Infrared (IR) Camera Assembly – 67212MFAN16000
42. Rack Attachment Plate – 67212MFAH41000
43. Center Post – 67212MFAH42000
44. ATCU Rack Attachment – 67211MFAG50000
45. ARIS Pins – 67211MFAG60000
46. GC Gas Supply Package – Argon – 67212MFAM31000
47. GC Gas Supply Package – Helium – 67212MFAM32000
48. GC Gas Supply Package – Check Gas – 67212MFAM33000

3.1.7 Government furnished property list.

The below list gives the government furnished major components of the CIR:

1. Electrical Power Control Unit (EPCU) – EP4001-9
2. Spacecraft Acceleration Measurement System (SAMS) Free Flyer – 60005MA12100

3.1.8 Government loaned property list.

Not applicable.

3.1.9 Program furnished property list.

The below list gives the program furnished major components of the CIR:

1. International Standard Payload Rack (ISPR) – 683-50243
2. Active Rack Isolation System (ARIS) – 683-61600

3.2 Characteristics.

3.2.1 Performance characteristics.

The CIR shall meet the performance characteristics requirements as specified herein from the requirements in FCF-DOC-002, with the interfaces necessary to accommodate PI hardware, software and resources, and FCF-SPC-0001.

3.2.1.1 Minimum utilization.

The CIR, interfacing with applicable PI hardware and resources, shall be designed to support a minimum utilization of five combustion basis experiments as specified in FCF-DOC-002.

3.2.1.2 Additional utilization.

The CIR, interfacing with applicable hardware and resources, shall be capable of accommodating a minimum of five additional combustion experiments from commercial and/or international sources. This requirement assumes the combustion experiments from commercial and/or international sources are similar to the basis experiments in paragraph 3.2.1.1.

3.2.1.3 Basis experiment capacity.

The CIR, interfacing with applicable PI hardware and resources, shall be designed to meet a minimum of 80% of the combustion basis experiments' test matrices using the combustion basis experiments as specified in FCF-DOC-002.

3.2.1.4 Combustion chamber science volume.

The CIR combustion chamber science volume shall have a minimum volume of 100 liters.

3.2.1.5 Combustion chamber science width.

The CIR combustion chamber internal minimum dimensions shall be no less than 45 cm in length and 20 cm in diameter.

3.2.1.6 Combustion chamber internal cleanliness.

3.2.1.6.1 Initial combustion chamber internal cleanliness.

The initial CIR combustion chamber internal cleanliness shall be maintained Visibly Clean – Sensitive (VC – S) from the time of shipment to the launch facility until the CIR is set up for its first experiment.

3.2.1.6.2 Combustion chamber cleanliness on orbit.

The CIR combustion chamber internal cleanliness on orbit shall be maintained to meet the optical science requirements.

3.2.1.7 Fuel/oxidizer storage.

a. The CIR shall be designed to provide gaseous fuel, oxidizer, and diluent storage.
b. The CIR shall be designed to provide PI interfaces to accommodate storage of gaseous, liquid and solid fuels, oxidizers, and diluents listed below within the safety constraints specified by the FCF Project and in paragraph 3.3.6.30:
    1. Oxygen
    2. Nitrogen
    3. Carbon dioxide
    4. Sulfur hexafluoride
    5. Helium
    6. Argon
    7. Hydrogen
    8. Methane
    9. Propane
    10. Ethylene
    11. Propanol
    12. Butanol
    13. n-decane
    14. Heptane
    15. Methanol
    16. Acetylene/nitrogen
    17. Propylene/nitrogen
    18. Toluene
    19. Filter paper (cellulose)
    20. Polyethylene
    21. Plastic composites
    22. Polymethylmethacrylate

3.2.1.8 Gas distribution.

a. The CIR shall provide for control and delivery ISS nitrogen to the combustion chamber.
b. The CIR shall provide for control and delivery of PI-provided gases given in paragraph 3.2.1.7b to the combustion chamber.

3.2.1.9 Gas mixing.

The CIR shall be designed to provide mixing of gases inside the combustion chamber.

3.2.1.10 Ignition interface.

a. The CIR shall provide at least one interface capable of supplying 28 Vdc power and a control interface for igniting fuel/oxidizer mixtures to the PI-specific hardware.
b. The CIR shall provide a combustion chamber port capable of supplying 120 Vdc power and a control interface for igniting fuel/oxidizer mixtures to the PI-specific hardware.

3.2.1.11 Science acceleration and vibration.

The CIR shall be capable of maintaining an acceleration and vibration environment to the combustion chamber walls as shown in Figure 7 during the operation of experiment test points.

3.2.1.12 Combustion chamber pressure.

The CIR combustion chamber shall be designed to provide pressure control from 0.02 to 3 atm (± 5% for any measurement within the range).

3.2.1.13 Containment pressure.

The CIR shall be designed to contain a minimum pressure of 9 atm.

3.2.1.14 Initial gas temperatures.

a. The CIR shall be designed to deliver gases with an initial temperature range from 278 to 318 K to the combustion chamber.
b. The CIR shall be designed to provide 28 VDC electrical power, data and control interfaces and cooling water interfaces as specified in 3.2.2.9.4.1 to allow PI control of gas temperatures from 268 to 320 K.

3.2.1.15 Condensed phase fuel temperatures.

The CIR shall be designed to provide 28 VDC electrical power, data and control interfaces and cooling water interfaces as specified in 3.2.2.9.4.1 to allow PI control of condensed phase fuel temperatures from 268 to 315 K.

3.2.1.16 Science oxygen compatibility.

The CIR internal gas supply system, gas chromatograph, combustion chamber, and exhaust vent hardware shall be compatible with oxygen at a concentration no less than 70%.

3.2.1.17 Gas blending.

a. The CIR shall be designed to provide partial pressure gas blending capability of oxidizer with diluents from 0 to 70% (± 2.0% absolute) oxidizer concentration.
b. The CIR shall be designed to provide dynamic gas blending capability of oxidizer with diluents from 0 to 25% (± 1.0% absolute) oxidizer concentration.

c. The CIR shall be designed to provide dynamic gas blending capability of oxidizer with diluents from 0 to 70% (± 2.0% of reading) oxidizer concentration.

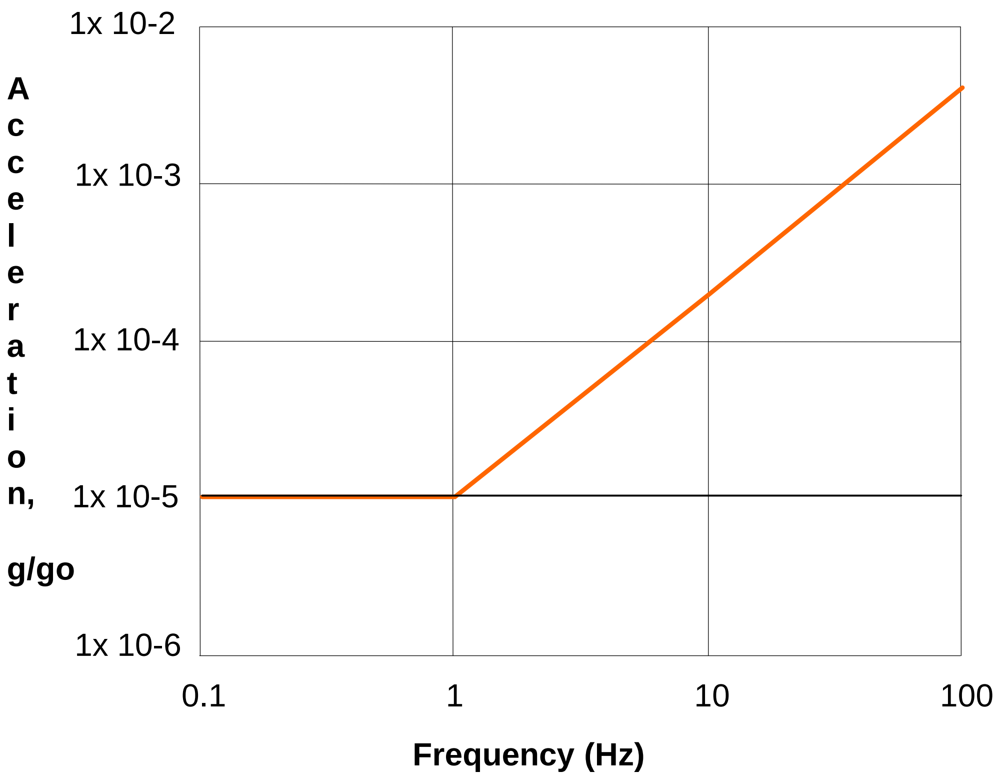


Figure 7. Acceptable minimum CIR acceleration and vibration levels

3.2.1.18 Premixed gases.

The CIR shall be designed to dispense premixed gases from gas bottles within the safety constraints specified by the FCF Project and in paragraph 3.3.6.30.

3.2.1.19 Gaseous fuel flow.

The CIR shall be designed to control gaseous fuel flow from 0 to 30 scc/s (± 5% for any measurement within the range) of the set point.

3.2.1.20 Gaseous oxidizer/diluent flow.

a. The CIR shall control gaseous oxidizer/diluent flow to the combustion chamber in a range from 0 to 1,500 scc/s ± 5% of the set point.
b. The CIR shall provide interfaces to allow the use of PI hardware to control the oxidizer/diluent flow within the combustion chamber in a range from 0 to 4,000 scc/s.

c. The CIR shall be capable of an oxidizer/diluent flow of at least 1,500 scc/s from the combustion chamber provided the gas meets the constraints specified in paragraph 3.2.2.9.4.2.
d. The CIR shall be capable of an oxidizer/diluent flow of at least 300 scc/s from the combustion chamber through an adsorber cartridge in order to meet meets the constraints specified in paragraph 3.2.2.9.4.2.

3.2.1.21 Constant oxidizer concentration within the combustion chamber.

The CIR shall be able to maintain constant oxidizer concentration within the combustion chamber to 1% of the desired set point during combustion events when the oxidizer replenishment rate is less than 0.3 <TBD 03-02> grams/s and the total oxidizer replenishment does not exceed 600 grams.

3.2.1.22 Number and duration of test points.

The CIR shall be capable of providing the following capacities to support the number and duration of test points in accordance with the combustion basis experiments as specified in FCF-DOC-002:

1. 60 Gbytes image processing storage
2. 120 Gbytes portable data storage
3. 2.25 liter fuel storage
4. 3.80 liter oxidizer storage
5. 3.80 liter diluent storage

3.2.1.23 Imaging and image measurement.

a. The CIR imaging and image measurement capability shall be designed to permit positioning for orthogonal and near-orthogonal views with respect to other imaging hardware.
b. The CIR imaging and image measurement capability shall mate with dimensionally controlled positional interfaces on the mounting surface and align with the combustion chamber windows.
c. The CIR imaging and image measurement capability shall operate from CIR common interfaces for power and control.
d. The CIR imaging and image measurement capability shall use common interfaces with CIR image and data acquisition systems.
e. The CIR imaging and image measurement capability shall use digital output imagers.
f. The CIR imaging and image measurement capability shall provide common interfaces that permit on-orbit hardware reconfiguration within an assembly for changes in selected performance ranges.
g. The CIR shall provide an analog imaging interface through the combustion chamber.

3.2.1.23.1 Color imaging.

a. The CIR color imaging capability shall provide a spectral range of 400-700 nm.

b. The CIR color imaging capability shall have a square field of view from 90 to 180 mm with a corresponding maximum resolution range of 2.5 to 1 line pairs/mm.
c. The CIR color imaging capability shall have a field of view from 175 mm square to 350 mm diameter (962 cm^2) with a corresponding maximum resolution range of 1 to 0.5 line pairs/mm.
d. The CIR color imaging capability shall provide an interface that permits attachment of PI hardware to provide a 1000 cm^2 field of view and a 350 mm square field of view.

e. The CIR color imaging capability shall have a motorized focus.
f. The CIR color imaging capability shall have a motorized aperture for exposure control.
g. The CIR color imaging capability shall have a frame rate range from 0.1 to at least 30 frames/second.
h. The CIR color imaging capability shall have a run time of at least18 minutes at 30 fps.

3.2.1.23.2 Visible spectrum high frame rate black and white imaging.

a. The CIR visible spectrum high frame rate black and white imaging capability shall provide a spectral range of from 400 to 1000 nm at 5% transmission response.
b. The CIR visible spectrum high frame rate black and white imaging capability shall have an instantaneous field of view 9 mm square steerable over a 35 mm square total field that is truncated at the corners by a 46 mm diameter circle.
c. The CIR visible spectrum high frame rate black and white imaging capability shall have a total field area of 12 cm^2.
d. The CIR visible spectrum high frame rate black and white imaging capability shall provide interfaces that permit attachment of PI provided hardware to provide a 16 cm^2 field of view and a 35 cm square field of view.
e. The CIR visible spectrum high frame rate black and white imaging capability shall have a resolution of 27.8 line pairs/mm at Nyquist limit binned.
f. The CIR visible spectrum high frame rate black and white imaging capability shall use motorized steering of the instantaneous field of view for automatic tracking at 10 mm/s.
g. The CIR visible spectrum high frame rate black and white imaging capability shall use motorized focus over a 30 mm depth range in object space.
h. The CIR visible spectrum high frame rate black and white imaging capability shall provide an interface that permits attachment of PI provided hardware to provide a 40 mm focus range.
i. The CIR visible spectrum high frame rate black and white imaging capability shall provide a telecentric optical system to account for droplet drift perpendicular to the imaging plane.
j. The CIR visible spectrum high frame rate black and white imaging capability shall provide an interface for a PI provided liquid crystal tunable filter.
k. The CIR visible spectrum high frame rate black and white imaging capability shall have a frame rate range from 1 to 100 frames/second binned; to 30 frames/second not binned.
l. The CIR visible spectrum high frame rate black and white imaging capability shall have a programmable control of frame rate including closed loop sensing with event trigger.
m. The CIR visible spectrum high frame rate black and white imaging capability shall have a run time of 15 minutes at 30 and at 100 fps.

3.2.1.23.3 High bit depth multispectral black and white imaging.

a. The high bit depth multispectral black and white imaging capability shall have a spectral range from 650 to1000 nm tunable with a liquid crystal tunable filter.
b. The high bit depth multispectral black and white imaging capability shall provide spectral range of 400 to 1000 at 5% transmission response with no liquid crystal tunable filter.
c. The high bit depth multispectral black and white imaging capability shall have a field of view 80 mm diameter with a corresponding maximum resolution of 5 line pairs/mm with a liquid crystal tunable filter.
d. The high bit depth multispectral black and white imaging capability shall have a field of view 50 mm square with a corresponding maximum resolution of 10 line pairs/mm without a liquid crystal tunable filter.
e. The high bit depth multispectral black and white imaging capability shall provide interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 50 to 200 cm^2 field of view or a 3.3 to 5 cm square field of view or a 5.6 to 16 cm square field of view.
f. The high bit depth multispectral black and white imaging capability shall provide interfaces that permit attachment of PI imager hardware to provide 0.018 mm resolution at FOVs from 18 to 35 mm at greater than 15 fps.
g. The high bit depth multispectral black and white imaging capability shall have a depth of field maximum of 110 mm at a resolution of 1 line pair/mm maximum with an 80 mm field of view.
h. The high bit depth multispectral black and white imaging capability shall have a depth of field minimum of 20 mm at a resolution of 10 line pairs/mm with a 50 mm field of view.
i. The high bit depth multispectral black and white imaging capability shall have a manual aperture adjustment for exposure or depth of field control.
j. The high bit depth multispectral black and white imaging capability shall have a framing rate of 15 frames/second (without spectral tuning).
k. The high bit depth multispectral black and white imaging capability shall have a bit depth of 12.
l. The high bit depth multispectral black and white imaging capability shall have a run time of at least 20 minutes at 15 fps.

3.2.1.23.4 Near ultraviolet (UV) imaging.

a. The near UV imaging capability shall have a spectral range of 250 to 700 nm.
b. The near UV imaging capability shall provide an interface for manual insertion of spectral filters.
c. The near UV imaging capability shall have a spectral filter with a 310 nm peak with 10 nm width at half maximum transmission.
d. The near UV imaging capability shall have a field of view 100 mm square with a corresponding maximum resolution of 1.8 line pairs/mm binned and 2.8 line pairs/mm not binned.
e. The near UV imaging capability shall have a field of view 42 mm square with a corresponding maximum resolution of 4.3 line pairs/mm binned and 6.7 line pairs/mm not binned.

f. The near UV imaging capability shall provide interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 100 to 1000 cm^2 field of view or a 10 to 35 cm square field of view or a 1.9 to 4.2 cm square field of view.
g. The near UV imaging capability shall provide interfaces that permit attachment of PI imager hardware to provide 0.5 mm resolution at field of views from 20 to 35 cm at 60 fps and 0.2 to 0.5 mm resolution at field of views from 10 to 20 cm at 30 fps and 0.05 to 0.18 mm resolution at field of views from 1.9 to 4.5 cm at up to 100 fps.
h. The near UV imaging capability shall have a depth of field maximum of 51mm at a resolution of 1 line pair/mm maximum with a 100 mm field of view.
i. The near UV imaging capability shall have a depth of field minimum of 5 mm at a resolution of 6.7 line pairs/mm with a 42 mm field of view.
j. The near UV imaging capability shall have a manual aperture adjustment for exposure or depth of field control.
k. The near UV imaging capability shall have a manual focus adjustment.
l. The near UV imaging capability shall have a maximum binned framing rate of 60 frames/s.
m. The near UV imaging capability shall have a maximum full resolution framing rate of 30 frames/s.
n. The near UV imaging capability shall provide interfaces that permit attachment of PI imager hardware to provide frame rates from 60 to 100 fps.
o. The near UV imaging capability shall have a bit depth of 8.
p. The near UV imaging capability shall have a run time of 40 minutes at 60 fps (binned).
q. The near UV imaging capability shall have a run time of 20 minutes at 30 fps (full resolution).

3.2.1.23.5 Near infrared (IR) imaging.

a. The near IR imaging capability shall have a spectral range from 400 to 900 nm.
b. The near IR imaging capability shall have an interface for manual insertion of spectral filters.
c. The near IR imaging capability shall have a square field of view from 45 to 90 mm with a corresponding maximum resolution range binned of 4.3 to 2.2 line pairs/mm.
d. The near IR imaging capability shall have a square field of view from 90 to 180 mm with a corresponding maximum resolution range binned of 2.2 to 1.1 line pairs/mm.
e. The near IR imaging capability shall provide interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 324 to 700 cm^2 field of view or an 18 to 35 cm square field of view.
f. The near IR imaging capability shall provide interfaces that permit attachment of PI imager hardware to provide 0.5 mm resolution for field of views from 20 to 30 cm at 60 fps and 0.2 mm resolution for field of views from 8 to 35 cm at 60 fps.
g. The near IR imaging capability shall have a depth of field maximum of 35 cm at a resolution of 1 line pair/mm maximum with a 45 mm field of view.
h. The near IR imaging capability shall have a depth of field minimum of 20 mm at a resolution of 2 line pairs/mm with a 180 mm field of view.
i. The near IR imaging capability shall have a motorized focus.
j. The near IR imaging capability shall have a motorized aperture for exposure control.

k. The near IR imaging capability shall have a maximum frame rate of 60 frames/second (binned).
l. The near IR imaging capability shall have a maximum frame rate of 30 frames/second (full resolution).
m. The near IR imaging capability shall have a bit depth of 8.
n. The near IR imaging capability shall have a maximum run time of 40 minutes at 60 fps (binned).
o. The near IR imaging capability shall have a maximum run time of 20 minutes at 30 fps (full resolution).

3.2.1.23.6 Mid IR imaging.

a. The mid IR imaging capability shall have a spectral range from 1000 to5000 nm. (See Appendix G for exceptions to this requirement.)
b. The mid IR imaging capability shall have an interface for manual insertion of spectral filters.
c. The mid IR imaging capability shall have an interface for mounting a filter wheel.
d. The mid IR imaging capability shall provide interfaces for PI provided imagers and optics operating in the spectral range from 8000 to 14000 nm.
e. The mid IR imaging capability shall have a field of view 180 x 135 mm with a corresponding maximum resolution of 0.9 line pairs/mm.
f. The mid IR imaging capability shall provide interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 240 to 1000 cm^2 field of view or an 18 to 35 cm axial and/or a 13.5 to 35 cm lateral field of view.
g. The mid IR imaging capability shall provide interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 0.2 to 0.3 mm resolution for field of views from 1.9 to 3.1 cm.
h. The mid IR imaging capability shall provide interfaces that permit attachment of PI imager hardware to provide 0.08 to 0.5 mm resolution for field of views from 10 to 35 cm at 60 fps.
i. The mid IR imaging capability shall have a depth of field maximum of 350 mm at a resolution of 0.25 line pairs/mm maximum with a 183 mm axial field of view.
j. The mid IR imaging capability shall have a depth of field minimum of 5 mm at a resolution of 0.9 line pairs/mm with a 183 mm field of view.
k. The mid IR imaging capability shall have a maximum frame rate of 60 frames/second.
l. The mid IR imaging capability shall have a bit depth of 12.
m. The mid IR imaging capability shall have a run time of 200 minutes at 60 fps.

3.2.1.23.7 Image illumination.

a. The image illumination capability shall have a field of view 80 mm diameter.
b. The image illumination capability shall have a spectral range from 650 to 1000 nm.
c. The image illumination capability shall be collimated.
d. The image illumination capability shall include laser diode source.

3.2.1.24 Gas phase temperature point measurements.

The CIR shall provide gas phase temperature point measurement interfaces in 12 separate locations to support PI provided gas phase temperature measurements.

3.2.1.25 Condensed phase temperature point measurements.

The CIR shall provide condensed phase temperature point measurement interfaces in 20 separate locations to support PI provided gas phase temperature measurements.

3.2.1.26 Gas phase temperature field measurements.

a. The CIR shall provide gas phase temperature field measurement range from 280 to 1,773 K with a temperature measurement resolution range from 10 to 100 K.
b. The CIR shall provide interfaces for PI-provided gas phase temperature field measurements over a temperature range from 1,773 to 2,900 K can be achievable through hardware changes.
c. The CIR shall provide interfaces to enable PI-provided spectral filtering of the measurements.

3.2.1.26.1 Gas phase temperature field measurement sampling rate.

The CIR shall provide a gas phase temperature field measurement sample rate range from 1 to 60 measurements/s.

3.2.1.26.2 Gas phase temperature field measurement spatial resolution.

a. The CIR shall provide a gas phase temperature field measurement resolution range from 0.5 to 2 mm.
b. The CIR shall provide interfaces that permit a spatial resolution range from 0.08 to 2 mm to be achievable with hardware changes.

3.2.1.26.3 Gas phase temperature field measurement lateral field of view.

a. The CIR shall provide a gas phase temperature field measurement lateral field of view range from 2.9 to 13 cm.
b. The CIR shall provide interfaces that permit a PI-provided lateral field of view range from 13 to 20 cm to be achievable with hardware changes.

3.2.1.26.4 Gas phase temperature field measurement axial field of view.

a. The CIR shall provide a gas phase temperature field measurement axial field of view range from 0.5 to 18 cm.
b. The CIR shall provide interfaces that permit a PI-provided axial field of view range from 18 to 20 cm to be achievable with hardware changes.

3.2.1.27 Condensed phase temperature field measurements.

a. The CIR shall provide condensed phase temperature field measurements from 260 to 1,300 K with temperature resolution range from 5 to 60 K.

b. The CIR shall provide a dimensionally controlled positional interface to the combustion chamber.
c. The CIR shall provide interfaces to enable spectral filtering of the measurements.
d. The CIR shall provide interfaces so that a PI-provided high resolution condensed phase temperature field measurement capability with a resolution range from 0.2 to 5 K can be achievable with hardware changes.

3.2.1.27.1 Condensed phase temperature field measurement sampling rate.

The CIR shall provide a condensed phase temperature field measurement sampling rate range from 1 to 60 measurements/s.

3.2.1.27.2 Condensed phase temperature field measurement spatial resolution.

a. The CIR shall provide a condensed phase temperature field measurement resolution range from 0.5 to 2 mm.
b. The CIR shall provide interfaces that permit PI-provided a condensed phase temperature field measurement resolution range from 0.2 to 0.5 mm.

3.2.1.27.3 Condensed phase temperature field measurement lateral field of view.

The CIR shall provide a condensed phase temperature field measurement lateral field of view range from 2.8 to 12 cm.

3.2.1.27.4 Condensed phase temperature field measurement axial field of view.

a. The CIR shall provide a condensed phase temperature field measurement axial field of view range from 5 to 18 cm.
b. The CIR shall provide interfaces that permit an axial field of view range from 18 to 20 cm achievable through hardware changes.

3.2.1.28 Pressure measurements.

The CIR, interfacing with applicable PI hardware, shall be capable of measuring pressures inside the combustion chamber from at least four separate locations.

3.2.1.28.1 Pressure measurement sampling rate.

The CIR shall be capable of pressure measurement sampling at a rate of 1 measurements/s.

3.2.1.28.2 Pressure measurement range.

The CIR shall be capable of measuring pressures within the combustion chamber from 0.01 to 8 atm with the accuracy ± 0.005 atm.

3.2.1.29 Chemical composition measurements.

The CIR shall be capable of sampling and measuring gases from the combustion chamber in a pressure range from 0.5 to 3 atm.

3.2.1.29.1 Chemical composition measurement constituents.

a. The CIR shall be capable of measuring, as a minimum, the following compounds:

1. Hydrogen
2. Methane
3. Propane
4. Oxygen
5. Nitrogen
6. Carbon monoxide
7. Carbon dioxide
8. Sulfur hexafluoride

b. The CIR shall provide an interface through the combustion chamber for PI provided water vapor measurement.

3.2.1.29.2 Gas composition measurement range.

The CIR, interfacing with the applicable PI hardware, shall be capable of measuring the gas constituents in a range from 0.1 to 100% (± 2% for any measurement within the range) of the measured concentration.

3.2.1.30 Soot measurements.

a. The CIR shall provide non-intrusive soot volume fraction distribution measurements with a dimensionally controlled positional interface to the combustion chamber.
b. The CIR shall provide spectral filtering of the soot volume faction measurements.
c. The CIR shall provide illumination for the soot volume fraction measurements.
d. The CIR shall provide non-intrusive soot temperature measurements with a dimensionally controlled positional interface to the combustion chamber.
e. The CIR shall provide spectral filtering of the soot temperature measurements.

3.2.1.30.1 Soot volume fraction measurement lateral field of view.

The CIR shall provide a lateral field of view range from 2.5 to 4 cm with a resolution range from 0.1 to 1 mm.

3.2.1.30.2 Soot volume fraction measurement axial field of view.

a. The CIR shall provide an axial field of view range from 0.03 to 8 cm with a resolution range from 0.1 to 3 mm.
b. The CIR shall provide interfaces that permit a PI-provided axial field of view range from 0.3 to 9 cm achievable through hardware changes.

3.2.1.31 Radiometry measurements.

The CIR shall provide five interfaces for PI-provided radiometry measurements.

3.2.1.32 Velocity point measurements.

a. The CIR shall provide 20 interfaces for PI-provided velocity point measurements.
The CIR shall provide interfaces to support PI-provided particle illumination and illumination delivery devices.

3.2.1.33 Full field velocity imaging.

a. The CIR shall provide interfaces for full field velocity imaging.
b. The CIR shall provide interfaces to enable PI-provided spectral filtering of images.
c. The CIR shall provide interfaces to support PI-provided particle illumination and illumination delivery devices.

3.2.1.33.1 Full field lateral field of view.

The CIR shall provide interfaces for selecting a lateral field of view range from 2 to 12 cm.

3.2.1.33.2 Full field axial field of view.

The CIR shall provide interfaces for selecting an axial field of view range from 2.5 to 16 cm.

3.2.1.34 Acceleration measurements.

The CIR shall be capable of monitoring residual accelerations and g-jitter from 10^{-6} to 10^{-2} g/g_0 with an accuracy range as as specified in SAMS-FF-DOC-101.

3.2.1.34.1 Acceleration measurement sampling rate.

The CIR shall be capable of measuring the accelerations at a sampling rate of 10, 25, 50, 100, 200, 400, or 800 Hz as specified in SAMS-FF-DOC-101.

3.2.1.35 Data time reference.

a. The CIR shall be capable of referencing all data collected by the CIR, including digital images, to ISS-related mission time.
b. The CIR shall provide an interface to make the time reference available to all applicable PI hardware.

3.2.1.35.1 Data time reference for experiment events.

a. The CIR shall be designed to have a time reference resolution of $\pm$ 0.001 s for experiment events.

b. The CIR shall provide an interface to make the time reference available to applicable PI hardware.

3.2.1.35.2 Data time reference for external events.

a. The CIR shall be designed to have a time reference resolution of ± 1 s for external events.
b. The CIR shall provide an interface to make the time reference available to applicable PI hardware.

3.2.1.36 Simultaneous measurements.

a. The CIR shall be capable of simultaneously providing up to 8 field measurement interfaces outside the combustion chamber and a minimum of 35 single sensor measurement interfaces inside the combustion chamber.
b. The CIR shall simultaneously provide control and measurement interfaces to allow applicable PI hardware to operate inside and outside the combustion chamber.

3.2.1.37 On orbit instrument calibration.

The CIR shall be capable of performing on orbit calibrations of instruments using standards traceable to the National Institute of Standards and Technology (NIST).

3.2.1.37.1 Replacement of on orbit instruments.

The CIR instrument hardware not capable of being calibrated on orbit shall be designed to be replaced with instruments calibrated to standards traceable to NIST.

3.2.1.38 Rack environment monitoring.

The CIR shall be designed collect data for downlinking to monitor the pressure, temperature, humidity, and acceleration within the CIR rack environment.

3.2.1.39 On-orbit data storage.

The CIR shall be capable of identifying all on orbit data as specified in paragraph 3.2.1.22 based on the basis experiments as specified in FCF-DOC-002.

3.2.1.40 On-orbit data collection and transfer.

3.2.1.40.1 Processing and providing data.

a. The CIR shall be capable of interfacing with the ISS to allow all on orbit data transfer for downlinking to the ground for use by the payload equipment and FCF ground crews and for data archiving prior to SAR deployment.

b. After SAR deployment, the CIR shall acquire, synthesize, and transfer science performance, configuration, status assessment, and message data to the SAR.
c. Prior to deployment of the SAR, during stand-alone operations, and in case of loss of the SAR to ISS communications, the CIR shall acquire, synthesize, and present science, performance, configuration, status assessment, and message data to the on orbit crew in the form of textual and graphic displays to the SSC.
d. Prior to SAR deployment and within the limited volume provided for image processing, the CIR shall be capable of processing scientific and engineering data in order to reduce the real-time, near real-time, and post-test bandwidth and duration necessary to transmit the data to the ground though the ISS. This processing should allow for (1) limiting the data streams though selection of duration and downlink sample rates by the FCF ground operations and payload equipment operation teams, for all data streams (2) downlinking data only when it is above, below, between, or outside a certain value(s) selected by the FCF ground operations and payload equipment operation teams, and (3) mission specific compression or data manipulation software code to be run. Note that this does not require the mission specific software code to be developed, only the capability to run such code when it is developed.
e. The CIR shall retain all data until commands are received from the FCF ground operations team indicating what data can be deleted or over-written.
f. The CIR shall be capable of providing, when requested by the FCF ground operations team, a summary of all data stored in the CIR, including identification of each measurement, time stamp/duration of data for each measurement, and file sizes.
g. The CIR shall be capable of sending image streams from scientific imaging devices in the CIR to the SAR for image processing and storage.

3.2.1.40.2 Image control and processing.

a. The CIR shall provide image and data acquisition for visible imaging that permits storage of image data without compression from 1 to 100 frames/s.
b. The CIR shall provide image and data acquisition for IR imaging that permits storage of image data without compression from 1 to 60 frames/s.
c. The CIR shall provide image and data acquisition for UV imaging that permits storage of image data without compression from 1 to 100 frames/s.
d. The CIR shall provide image and data acquisition for gas phase temperature measurements that permits storage data without compression from 1 to 1,000 measurements/s/measurement.
e. The CIR shall provide image and data acquisition for condensed phase temperature point measurements that permits storage of data without compression from 1 to 30 measurements/s/measurement.
f. The CIR shall provide image and data acquisition for gas phase temperature field measurements that permits storage of image data without compression from 1 to 60 frames/s.
g. The CIR shall provide image and data acquisition non-intrusive soot volume fraction distribution and soot temperature measurements that permits storage of image data without compression.
h. The CIR shall provide data acquisition for radiometry measurements that permits storage data without compression from 1 to 1,000 samples/s.
i. The CIR shall provide image and data acquisition for full field velocity imaging that permits storage of image data without compression from 30 to 60 frames/s.

j. The CIR shall provide a minimum capability of controlling four image streams.

3.2.1.40.3 On orbit data transfer within FCF.

The CIR shall be capable of accepting and transferring all data to the SAR at a minimum rate of 100 Mbits/s after SAR deployment.

3.2.1.40.4 On orbit data transfer to portable media.

The CIR shall be capable of transferring all stored data, as specified in paragraph 3.2.1.22 based on the basis experiments as specified in FCF-DOC-002, to portable media.

3.2.1.41 CIR health status monitoring.

a. The CIR shall be designed to monitor and transfer on orbit health status data of all assemblies with electrical and fluids interfaces to the Station Support Computer (SSC) and to the SAR and to transfer on orbit health status data to the ISS for downlinking when the CIR is powered and note any out-of-tolerance conditions.
b. The CIR shall collect and monitor health status data from all applicable PI assemblies and provide this data to the above interfaces.

3.2.1.41.1 CIR/FCF health status monitoring.

The CIR shall have the capability to interface with the SSC, to transfer to the SSC health status data of FCF systems that interface with the CIR, and to transfer the health status data to the ISS for downlinking when the CIR is powered and note any out-of-tolerance conditions.

3.2.1.41.1.1 Health status reporting to SAR.

The CIR shall report all out-of-tolerance conditions to the SAR after SAR deployment.

3.2.1.41.2 CIR/ISS health status monitoring.

The CIR shall have the capability to interface with the SSC, to transfer to the SSC its health status data of ISS systems that interface with the CIR, and to transfer the health status data to the ISS for downlinking when the CIR is powered and note any out-of-tolerance conditions.

3.2.1.42 CIR Commanding.

3.2.1.42.1 SSC Commanding.

a. The CIR shall be capable of accepting command inputs, acknowledging and validating the inputs, returning responses, and monitoring all CIR functions that use the SSC when the CIR is powered.
b. The CIR shall be capable of routing applicable commands to PI hardware.

3.2.1.42.2 Ground Commanding.

a. The CIR shall be capable of accepting command inputs, acknowledging and validating the inputs, and returning responses though the ISS-provided interfaces when the CIR is powered.
b. The CIR shall be capable of routing applicable commands to PI hardware.

3.2.1.42.3 Commanding though SAR.

a. The CIR shall be capable of accepting command inputs, acknowledging and validating the inputs, and returning responses using the SAR when the CIR is powered.
b. The CIR shall be capable of routing applicable commands to PI hardware.

3.2.1.42.4 Manual Inputs

The CIR shall provide the mechanical (switches, displays, etc.) equipment necessary for the on orbit crew to control the CIR.

3.2.1.43 Upgrading of CIR maintenance items.

The CIR shall be designed to allow for upgrading of components within the assemblies and other maintenance items within the CIR.

3.2.1.44 Control of CIR.

a. The CIR shall provide overall control as specified in Table III.
b. The CIR shall control all payload equipment placed within the CIR.

Table III. Control conditions

Capability	Control Conditions
Perform/support combustion science	Capability is not required to be continuous. Initiation of capability shall be though ground or on orbit crew command.
Process and provide data	Capability is not required to be continuous. Initiation of capability shall be though automated sequence or ground or on orbit crew command.
Respond to out-of-tolerance conditions	Capability is required to be continuous, whenever powered.
Withstand external environment changes	Capability is required to be continuous.
Accept commanding and manual inputs	Capability is required to be continuous, whenever powered.

Capability	Control Conditions
Maintenance/troubleshooting	Capability is not required to be continuous. Initiation of capability shall be though ground or on orbit crew command or on orbit crew operation.
Reconfigure CIR	Capability is not required to be continuous. Initiation of capability shall be though ground or on orbit crew command for software and on orbit crew operation for hardware.

3.2.2 Physical characteristics.

3.2.2.1 CIR dimensional characteristics.

3.2.2.1.1 CIR launch envelope.

The CIR in launch configuration shall not exceed the envelope as specified in SSP 41017 Part 1, paragraph 3.2.1.1.2.

3.2.2.1.2 CIR on orbit envelope.

The CIR, with applicable PI hardware, shall have an on orbit envelope as specified in SSP 41017 Part 1, paragraph 3.2.1.1.2 and shall follow the on orbit payload protrusion requirements as specified in SSP 57000, paragraph 3.1.1.7. (See Appendix G for exceptions to this requirement.)

3.2.2.1.3 CIR stowage volume.

a. The CIR shall not exceed a maintenance item stowage volume of 0.18 m^3.
b. The CIR shall provide a minimum of 0.11 m^3 of space for payload equipment within its envelope with an additional 0.01 m^3 of optionally available for use by payloads if they do not require Flight Segment provided diagnostics.

3.2.2.1.4 CIR maintenance item stowage up-volume.

The CIR maintenance items shall not exceed an up-volume of 1/3 standard rack equivalents.

3.2.2.2 CIR weight characteristics.

a. The CIR shall not exceed a launch mass of 804.2 kg (1773 lbs), excluding stowage hardware.
b. The CIR, with applicable PI hardware, shall not exceed an on orbit mass of 804.2 kg (1773 lbs), excluding stowage hardware. (See Appendix G for exceptions to this requirement.)
c. CIR spares and resupply equipment shall not exceed an up-mass of 125 kg (275 lbs).

3.2.2.3 CIR power.

a. The CIR, with applicable PI hardware, shall have the capability to use a maximum of 6,000 W of power.
b. The CIR, with applicable PI hardware, when integrated into the FCF, shall not exceed a power draw of 2,000 W. (See Appendix G for exceptions to this requirement.)

3.2.2.3.1 CIR environmental control system power allocation.

The CIR environmental control system power allocation shall not exceed, over a period of 30 minutes, 30 W or 8% of the input power to the CIR, whichever is greater.

3.2.2.3.2 CIR power to PI avionics.

The CIR shall provide a minimum of 2 channels of 8A, 28 Vdc power for PI avionics.

3.2.2.3.3 CIR power to PI hardware inside combustion chamber.

The CIR shall provide 3 channels 4A, 120 Vdc and 2 channels 8A, 28 Vdc power to operate experiments within the combustion chamber.

3.2.2.4 CIR heat rejection.

The CIR shall have the capability to reject a maximum of 6,000 W of power.

3.2.2.5 PI avionics cooling air.

The CIR shall provide a minimum of 450 W air cooling to PI avionics.

3.2.2.6 Thermal cooling water.

The CIR shall be capable of providing thermal water cooling with a minimum inlet temperature of 16.1°C (61.0°F) and a maximum outlet temperature of 48.9°C (120°F).

3.2.2.6.1 Thermal water cooling inside combustion chamber.

The CIR shall provide a PI interface capable of providing thermal water cooling to the interior of the combustion chamber at a minimum of 500 W capacity with a minimum inlet temperature of 16°C (60.8°F) and a maximum outlet temperature of 49°C (120°F).

3.2.2.7 Durability.

a. The CIR shall be designed to have a minimum operational life of 10 years after full deployment of the FCF, including regularly scheduled and unscheduled maintenance activities.

b. The CIR shall be designed to be capable of an extended life to 15 years after full deployment, including regularly scheduled and unscheduled maintenance activities and major component replacement.

3.2.2.8 Transportation and safety requirements.

This paragraph is covered in paragraph 3.2.7 and section 5.0.

3.2.2.9 Interfaces.

3.2.2.9.1 Interfaces within the US Lab.

The CIR shall interface with the ISS, PI hardware, and CIR internal assemblies in accordance with Table I, Table II, Appendix C, Appendix D, Appendix E, Appendix F, and FCF-IDD-CIR.

3.2.2.9.2 Ground support equipment (GSE) interfaces.

a. The CIR shall interface to the Kennedy Space Center (KSC) GSE Rack Insertion Device in accordance with SSP 41017 Part 1, paragraphs 3.2.1.1.2 and 3.2.1.4.3 and SSP 41017 Part 2, paragraphs 3.3.2 and 3.3.3.
b. The CIR shall interface to Rack Shipping Containers in accordance with the Teledyne Brown Engineering (TBE) as-built drawing 220G07500.
c. The CIR shall interface to Rack Handling Adapters (RHA) in accordance with the following TBE as-built drawings: 220G07455, 220G07470, and 220G07475.
d. The CIR shall be limited to ground transportation accelerations of 80% of flight accelerations defined by SSP 41017 Part 1, paragraph 3.2.1.4.2.

3.2.2.9.3 MPLM interfaces.

a. The CIR shall interface to the MPLM structural attach points in accordance with SSP 41017 Part 2, paragraph 3.1.1.
b. The CIR shall maintain positive margins of safety for MPLM depress rates of 890 Pa/s (7.75 psi/min) and repress rates of 800 Pa/s (6.96 psi/min).
c. The CIR shall be limited to producing interface attach point loads less than or equal to those identified by SSP 41017 Part 1, paragraph 3.2.1.4.3, based upon an acceleration environment as defined in SSP 41017 Part 1, paragraph 3.2.1.4.2.

3.2.2.9.4 ISS fluids and vacuum interface requirements.

3.2.2.9.4.1 Water Thermal Control System (WTCS).

a. Coolant contained in the WTCS that interfaces with ISS US Lab ITCS coolant shall satisfy the cleanliness and materials requirements specified below:
b. The WTCS shall use fluids that meet the requirements specified in SSP 30573.
c. The WTCS shall meet the fluid system cleanliness levels specified in SSP 30573.

d. The WTCS shall use internal materials that are compatible according to MSFC-SPEC-250, Table III or that will not create a potential greater than 0.25 V with the ISS system internal materials due to a dissimilar metal couple.
e. The WTCS shall be delivered on orbit and during transport charged with coolant as specified in paragraph 3.2.2.9.4.1 a. Integrated racks that are not actively serviced by the MPLM Thermal Control System during transport shall be charged to allow for thermal expansion between the temperatures of 1.67 and 46°C (35 and 114.8°F).
f. The WTCS shall be designed to meet the US Lab moderate temperature loop pressure drop specified in Figure 8 with both halves of each mated quick disconnect (QD) pair included as part of the payload pressure differential.
g. The WTCS shall be designed to meet the US Lab moderate temperature loop allowable flow rate: ITCS Selectable Coolant Flow Rate = 100 - 745 lbm/h (45 - 339 kg/h).
h. The WTCS shall be designed to meet the US Lab moderate temperature loop coolant supply temperature: ITCS Coolant Supply Temperature = 61 - 65 oF (16 - 18.3 oC).
i. The WTCS using moderate temperature coolant at operating modes above 1025 W shall have a minimum differential temperature across the integrated rack (inlet to outlet) of 19.5°C (35°F).
j. The WTCS using moderate temperature coolant shall be designed to operate using 100 lbm/h flow during operating modes which require less than 1025 W of power.
k. The maximum moderate temperature coolant return temperature shall be no greater than 49°C (120°F).
l. The WTCS shall withstand the moderate temperature loop MDP of 121 psia (834 kPa).
m. The WTCS shall assess the payload equipment and rack internal water loop piping to ensure that it is fail safe in the case of loss of cooling under all modes of operation.
n. The WTCS shall not exceed the maximum rack leakage rate of water of 14x10 -3 scc/ h (liquid) per each thermal loop at the MDP of 121 psia (834 kPa).
o. WTCS QD's shall not exceed the maximum air inclusion of .30 cc maximum per mate or demate operation.
p. The WTCS automated flow control systems shall be designed such that set point changes resulting in flow rate changes greater than 5 lbm/h shall take at least 100 s to reach 63.2% (i.e., 1 -e -1) of the commanded change in flow rate.
q. The WTCS shall contain no more than the maximum allowable coolant quantity of water, referenced at 61? C (141.8? F). The maximum allowable coolant quantity of water in the US Lab MTL is 42.25 gal. (159.9 L).
Note: Payload racks are to have a design target for total rack coolant volume of no more than 1.82 gal (6.90 L) on the MTL.
r. The WTCS shall not exceed the maximum allowable gas inclusion or volume at the MDP into the US Lab Internal Thermal Control System of 8.88 in3 (0.146 L).
s. The WTCS shall meet the physical and functional interfaces depicted in Figure 1 of the FSS Interface Definition Drawing (IDD), 683-17103.

3.2.2.9.4.2 Vacuum exhaust system/waste gas system(VES/WGS) requirements.

a. The CIR shall limit its vented exhaust gas to a pressure of 276 kPa (40 psia) or less at the rack to ISS interface.

b. The CIR volume connected to the VES/WGS shall be designed to a MDP of at least 276 kPa (40 psia) with safety factors in accordance with SSP 52005, paragraph 5.1.3.
c. The CIR shall be two failure tolerant to protect against failure conditions which would exceed VES/WGS max design pressure of 40 psia.
d. The initial temperature range of exhaust gases shall be between 16 and 45°C (60 and 113°F).
e. The initial dewpoint of exhaust gases shall be limited to 16°C (60°F) or less.

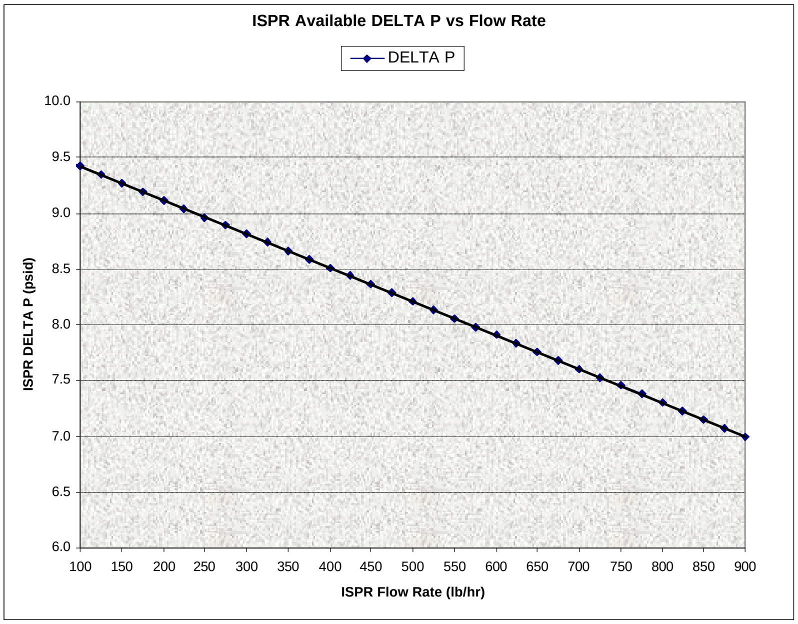


Figure 8. U.S.Lab MTL available pressure drop vs. flow rate

f. The CIR exhaust gases vented into the VES/WGS of the US Lab shall be compatible with the wetted surface materials of the respective laboratory(ies) in which the integrated rack will operate, as defined in SSP 41002, paragraph 3.3.7.2. (See Appendix G for exceptions to this requirement.)
g. The CIR shall be nonreactive with other vent gas mixture constituents.
h. The CIR shall provide a means of removing gases that would adhere to the ISS VES/WGS tubing walls at a wall temperature of 4°C (40°F) and at a pressure of 10 (-3) torr.
i. The CIR shall remove particulates from vent gases that are larger than 100 μm in size.
j. Gases venting from the CIR shall be in accordance with the list of acceptable exhaust gases with verified compatibility to the USL VES wetted materials as specified in SSP 57000 Appendix D1 and the list of unacceptable gases that are not compatible with the USL VES as specified in Appendix D2.
k. Exhaust gases shall be compatible with paragraph 3.4 of SSP 30426 for molecular column density, particulates, and deposition on external ISS surfaces.
l. The CIR shall provide containment, storage, and transport hardware for gases that are incompatible with the vacuum exhaust or external environment.
m. Containment hardware for incompatible exhaust gases shall meet the redundant container requirements specified in NSTS 1700.7 ISS Addendum, paragraph 209.1 b.

3.2.2.9.4.3 Vacuum resources system (VRS).

The CIR shall provide the physical interface to the VRS. PI's using the VRS are required to meets all applicable ISS VRS requirements.

3.2.2.9.4.4 ISS nitrogen usage requirements.

a. The CIR shall provide a means, located within the integrated rack envelope, to turn on and off the flow of nitrogen to the integrated rack and to control the flow of nitrogen to not exceed 5.43 kg/h (12 lbm/h) when connected to the nitrogen interface operating pressure range of 517 to 827 kPa (75 to 120 psia).
b. The MDP of the CIR interfacing with the nitrogen system shall be 1,379 kPa (200 psia).
c. The CIR nitrogen system shall be designed for a nitrogen supply temperature range of 15.6 to 45°C (60 to 113°F).
d. The CIR shall have a nitrogen leakage rate no greater than 10 -3 scc/s.

3.2.2.9.5 COF interfaces.

The CIR shall be capable of interfacing with the COF for structural, fluids, and electrical connections, but shall not be required to meet any of the performance requirements and physical requirements unless otherwise specified in SSP 57000.

3.2.2.9.6 CIR to SAR interface.

The CIR shall use an adapter, part no. MTP-ADPT connected to a MTFA-12M5 ferule inside a MTP-012M-SM housing to interface with the SAR to transfer data and receive commands from the SAR as described in paragraph 3.1.5.1.

3.2.2.9.7 SAMS data interface.

<TBD 03-03>

3.2.2.9.8 Use of FIR hardware.

The CIR shall not preclude the use of FIR hardware to meet science and project requirements.

3.2.3 Reliability.

Not applicable.

3.2.4 Maintainability.

The CIR shall not exceed <TBD 03-04> on orbit mean maintenance crew hours per year (MMCH/Y) for scheduled and unscheduled maintenance activities including inspections, preventative and corrective maintenance, restorations, and replacement of assemblies and components.

3.2.4.1 CIR maintenance access.

The CIR shall be designed to allow for the replacement of Orbital Replacement Units (ORU's) and failed components and the performance of other internal maintenance activities without rotating the CIR from its installed position within the US Lab. (See Appendix G for exceptions to this requirement.)

3.2.4.2 Maintenance item temporary restraint and stowage.

CIR maintenance items shall be designed to allow for temporary restraint and/or stowage during maintenance activities.

3.2.4.3 Tool usage for maintenance.

The CIR shall be designed to be maintained using the ISS tools as defined in SSP 57020.

3.2.4.4 Lockwiring and staking.

All CIR maintenance items shall not be lockwired or staked during installation.

3.2.4.5 Redundant paths.

The CIR, with applicable PI hardware, shall be designed to provide for alternate or redundant functional paths of all electrical and electronic harnesses that cannot be replaced on orbit.

3.2.4.6 CIR reconfiguration for out-of-tolerance conditions.

The CIR, with applicable PI hardware, shall be designed to allow visual and tactile access to all avionics hardware for at least one hour during troubleshooting operations without detrimental effects to the crew, the ISS, or CIR hardware.

3.2.5 Availability.

The CIR, with applicable PI hardware and spares, shall have an operational availability of 92.92% for a base operational life of 10 years with an extendable capability to 15 years in accordance with the formula:

A0 = MTBM/MTBM+MDT

Where MTBM = Mean Time Between Maintenance and MDT = Mean Delay Time.

3.2.6 Environmental conditions.

3.2.6.1 Shipping and storage environment.

3.2.6.1.1 Nonoperating atmospheric environment.

a. The CIR shall be designed to have a nonoperating temperature range from 2 to 50°C (35.6 to 122°F).
b. The CIR shall be designed to have a nonoperating pressure range from 0 to 104.8 kPa.
c. The CIR shall be designed to tolerate a relative humidity range from 10 to 90%.

3.2.6.1.2 Operating atmospheric environment.

a. The CIR shall be designed to have an operating temperature range from 17 to 30°C (35.6 to 122°F).
b. The CIR shall be designed to have an operating pressure range from 95.8 to 104.8 kPa.
c. The CIR shall be designed to an operating relative humidity range from 25 to 75%.

3.2.6.2 MPLM/on orbit environmental conditions.

The CIR, with the applicable PI hardware, shall meet the MPLM/on orbit environmental conditions as specified in Table IV.

3.2.6.3 On-orbit condensation.

The CIR shall be designed to not cause condensation when exposed to the ISS atmosphere ranging in dewpoint from 4.4 to 15.6°C (40 to 60°F) and in relative humidity from 25 to 75%.

3.2.6.4 Special environmental conditions.

3.2.6.4.1 Load requirements.

a. The CIR shall provide positive margins of safety for launch and landing load conditions in the MPLM based upon an acceleration environment as defined in SSP 41017 Part 1, paragraph 3.2.1.4.2. Loads should be consistently applied with the rack coordinate system defined in SSP 41017 Part 2, paragraph 3.1.3.
b. The CIR shall provide positive margins of safety for on orbit loads of 0.2 g acting in any direction.
c. Rack Utility Panel (RUP) umbilicals shall be restrained during launch and landing to prevent damage to loose connectors from loads and vibration.
d. CIR equipment shall provide positive margins of safety when exposed to the crew-induced loads defined in Table VI.
e. For design and qualification purposes, components mounted to ISPR posts shall maintain positive margins of safety for the MPLM launch random vibration environment as defined in Table VII or Table VIII.

Table IV. MPLM/on orbit environmental conditions

Environmental Condition	Value	
Atmospheric Conditions on ISS		
Pressure Extremes	0 to 104.8 kPa (0 to 15.2 psia)	
Normal operating pressure	See Figure 9	
Oxygen partial pressure	See Figure 9	
Nitrogen partial pressure	See Figure 9	
Dewpoint	4.4 to 15.6°C (40 to 60°F) ref. Figure 10	
Percent relative humidity	25 to 75% ref. Figure 10	
Carbon dioxide partial pressure during normal operations with 6 crewmembers plus animals	24-h average exposure 5.3 mm Hg Peak exposure 7.6 mm Hg	
Carbon dioxide partial pressure during crew changeout with 11 crewmembers plus animals	24-h average exposure 7.6 mm Hg Peak exposure 10 mm Hg	
Cabin air temperature in USL, JEM, APM, and CAM	17 to 28°C (63 to 82°F)	
Cabin air temperature in Node 1	17 to 31°C (63 to 87°F)	
Air velocity (Nominal)	0.051 to 0.203 m/s (10 to 40 ft/min)	
Airborne microbes	Less than 1000 CFU/m3	
Atmosphere particulate level	Average less than 100,000 particles/ft3 for particles less than 0.5 microns in size	
MPLM Air Temperatures	**Passive Flights**	**Active Flights**
Pre-Launch	15 to 24°C (59 to 75.2°F)	14 to 30°C (57.2 to 86°F)
Launch/Ascent	14 to 24°C (57.2 to 75.2°F)	20 to 30°C (68 to 86°F)
On orbit (Cargo Bay + Deployment)	24 to 44°C (75.2 to 111.2°F)	16 to 46°C (60.8 to 114.8°F)
On orbit (On-Station)	23 to 45°C (73.4 to 113°F)	16 to 43°C (60.8 to 109.4°F)
On orbit (Retrieval + Cargo Bay)	17 to 44°C (62.6 to 111.2°F)	11 to 45°C (51.8 to 113°F)
Descent/Landing	13 to 43°C (55.4 to 109.4°F)	10 to 42°C (50 to 107.6°F)
Post-Landing	13 to 43°C (55.4 to 109.4°F)	10 to 42°C (50 to 107.6°F)
Ferry Flight	15.5 to 30°C (59.9 to 86°F)	15.5 to 30°C (59.9 to 86°F)
MPLM Maximum Dewpoint Temperatures		
Pre-Launch	13.8°C (56.8°F)	12.5°C (54.5°F)
Launch/Ascent	13.8°C (56.8°F)	12.5°C (54.5°F)
On orbit (Cargo Bay + Deployment)	13.8°C (56.8°F)	12.5°C (54.5°F)
On orbit (On-Station)	15.5°C (60°F)	15.5°C (60°F)
On orbit (Retrieval + Cargo Bay)	10°C (50°F)	10°C (50°F)
Descent/Landing	10°C (50°F)	10°C (50°F)
Post-Landing	10°C (50°F)	10°C (50°F)
Ferry Flight	15.5°C (60°F)	15.5°C (60°F)
Thermal Conditions		
USL module wall temperature	13°C to 43°C (55°F to 109°F)	
JEM module wall temperature	13°C to 45°C (55°F to 113°F)	
APM module wall temperature	13°C to 43°C (55°F to 109°F) (TBR #4)	
CAM module wall temperature	13°C to 43°C (55°F to 109°F) (TBR #5)	
Other integrated payload racks	Front surface less than 37°C (98.6°F)	
*** Microgravity**		
Quasi-Steady State Environment	See Figure 11, Figure 12, and Table V	
Vibro-acoustic Environment	See Figure 13	
General Illumination	108 Lux (10 fc) measured 30 inches from the floor in the center of the aisle	

* Note: Data reflects best available information as of May, 1997. Does not include effects of CAM.

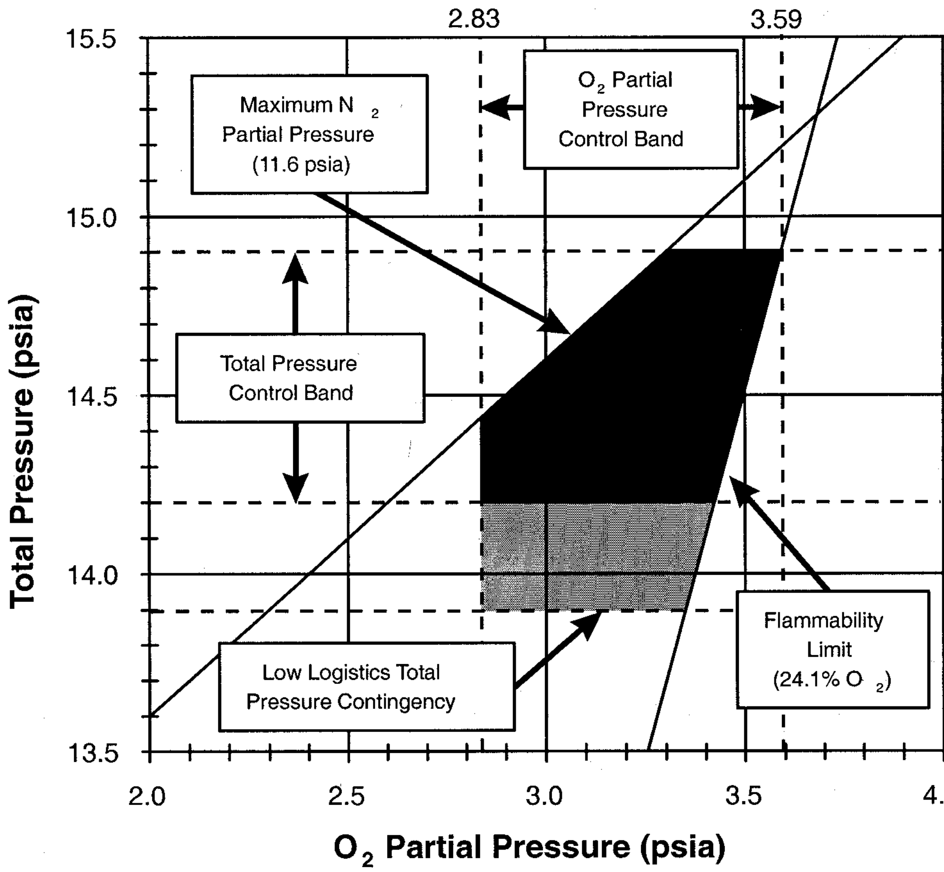


Figure 9. Operating limits of the ISS atmospheric total pressure, nitrogen, and oxygen partial pressures

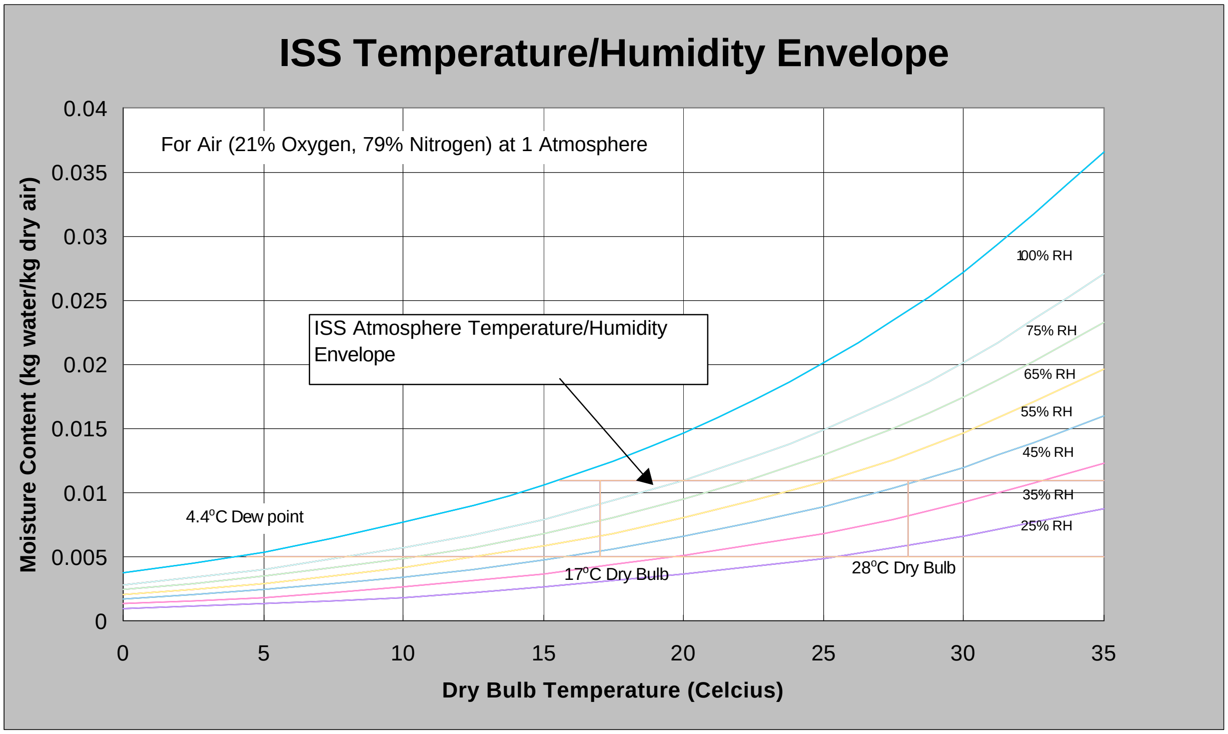


Figure 10. ISS temperature/humidity envelope

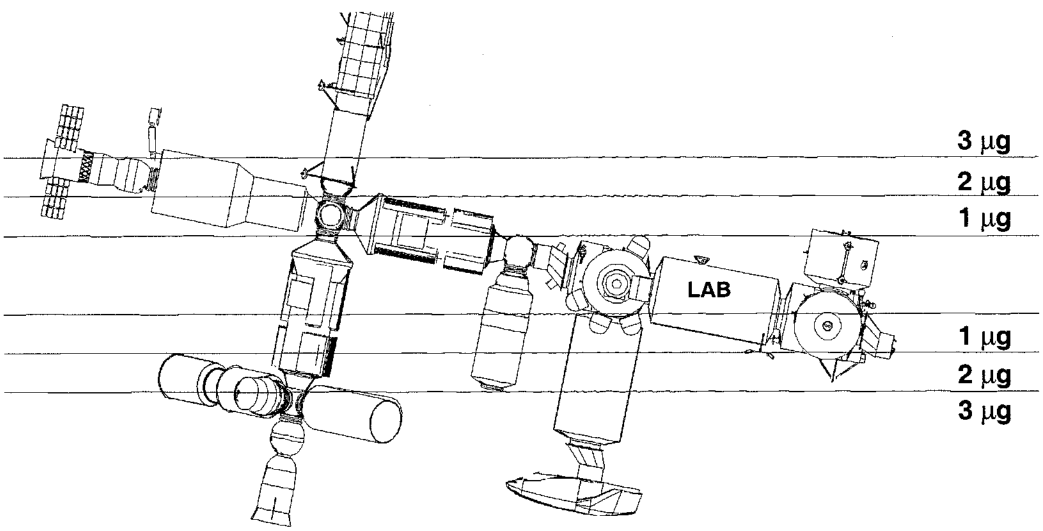


Figure 11. Assembly complete quasi-steady state microgravity contours (side)

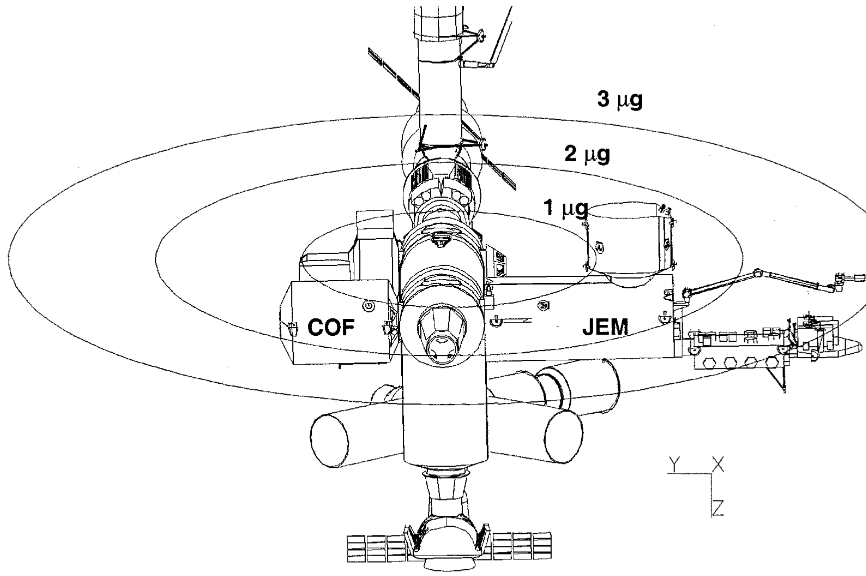
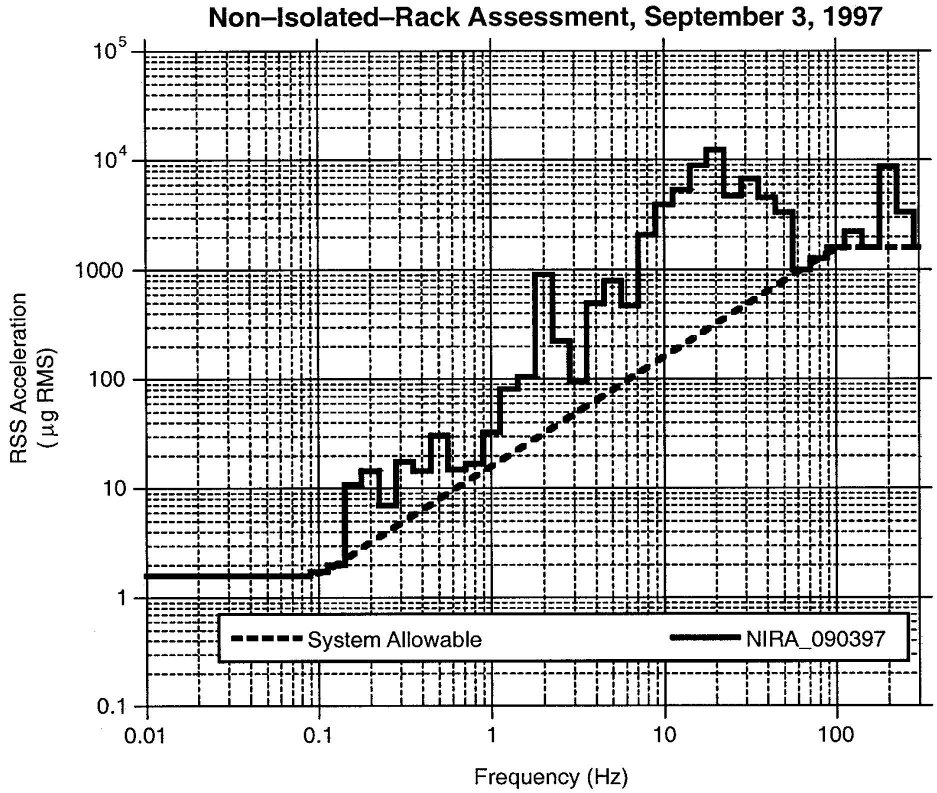


Figure 12. Assembly complete quasi-steady state microgravity contours (front)

Table V. Assembly complete quasi-steady state microgravity environment

Location (ISPRs)	Magnitude (μg)	Stability (μg)	Unit Vector Components X	Y	Z	Angle (deg)	Location (Others)	Magnitude (μg)	Stability (μg)	Unit Vector Components X	Y	Z	Angle (deg)
USL–C1	**0.525**	0.126	0.641	–0.109	0.760	17.370	USL–CG	0.793	0.137	0.466	–0.052	0.883	10.360
USL–C2	**0.468**	0.116	0.721	–0.133	0.680	20.710	APM–CG	1.624	0.157	0.288	–0.533	0.795	5.547
USL–C3	**0.419**	0.100	0.819	–0.165	0.549	24.820	APM–CLG1	1.010	0.151	0.350	–0.649	0.676	8.635
USL–C4	**0.380**	0.078	0.922	–0.204	0.330	28.370	APM–CLG2	1.120	0.154	0.313	–0.726	0.612	7.944
USL–C5	**0.356**	0.064	0.972	–0.237	–0.002	25.280	RS–FGB	1.119	0.139	–0.003	–0.060	–0.998	7.802
USL–S1	1.062	0.145	0.385	–0.227	0.895	7.927	RS–SM	2.179	0.129	–0.099	–0.038	–0.994	3.655
USL–S2	**0.989**	0.143	0.400	–0.248	0.883	8.421	JEM–CG	1.811	0.157	0.244	0.745	0.621	5.143
USL–S3	**0.917**	0.141	0.417	–0.272	0.867	8.973	JEF1–F1	2.954	0.165	0.223	0.627	0.746	3.325
USL–S4	**0.846**	0.138	0.437	–0.300	0.848	9.859	JEF2–A1	2.613	0.160	0.218	0.706	0.674	3.646
USL–P1	1.019	0.145	0.396	0.166	0.903	8.310	JEF3–F2	3.039	0.167	0.216	0.658	0.722	3.265
USL–P2	**0.945**	0.143	0.413	0.180	0.893	8.866	JEF4–A2	2.710	0.162	0.209	0.734	0.646	3.558
USL–P4	**0.799**	0.138	0.458	0.215	0.862	10.230	JEF5–F3	3.129	0.169	0.209	0.685	0.698	3.208
JPM1–A1	1.250	0.150	0.348	0.333	0.877	7.015	JEF6–A3	2.811	0.164	0.201	0.760	0.619	3.477
JPM2–F1	1.480	0.154	0.325	0.282	0.903	6.095	JEF7–F4	3.223	0.171	0.203	0.710	0.674	3.155
JPM3–A2	1.296	0.151	0.334	0.433	0.838	6.819	JEF8–A4	2.915	0.167	0.194	0.782	0.593	3.401
JPM4–F2	1.519	0.154	0.316	0.370	0.874	5.979	JEF9–O1	3.303	0.174	0.188	0.771	0.608	3.135
JPM5–A3	1.355	0.151	0.318	0.520	0.793	6.570	JEF10–O2	3.091	0.174	0.174	0.838	0.517	3.334
JPM6–F3	1.569	0.155	0.305	0.450	0.839	5.824	JEF11–U1	2.456	0.169	0.184	0.861	0.474	4.064
JPM7–A4	1.425	0.152	0.301	0.594	0.746	6.288	JEF12–U2	2.553	0.171	0.170	0.890	0.423	3.955
JPM8–A5	1.505	0.153	0.284	0.657	0.699	5.992	S3LO	3.299	0.223	0.038	–0.994	–0.104	3.918
JPM9–F5	1.700	0.156	0.280	0.584	0.762	5.441	S3LI	2.945	0.212	0.042	–0.991	–0.124	4.180
JPM10–F6	1.778	0.157	0.266	0.638	0.723	5.234	S3UO	3.958	0.209	–0.056	–0.846	–0.530	3.142
APM–FWD1	1.605	0.155	0.305	–0.386	0.871	5.573	S3UI	3.644	0.196	–0.062	–0.810	–0.584	3.222
APM–FWD2	1.681	0.157	0.291	–0.465	0.836	5.370	P3LO	3.260	0.191	0.022	0.973	–0.231	3.355
APM–FWD3	1.768	0.159	0.277	–0.532	0.800	5.167	P3UO	4.043	0.176	–0.068	0.780	–0.622	2.494
APM–FWD4	1.863	0.161	0.263	–0.590	0.763	4.968							
APM–AFT1	1.397	0.152	0.318	–0.451	0.834	6.275							
APM–AFT2	1.482	0.154	0.300	–0.534	0.791	5.989							
APM–AFT3	1.578	0.157	0.282	–0.603	0.747	5.709							
APM–AFT4	1.682	0.160	0.264	–0.659	0.704	5.450							

10 ISPRs Have Quasi–Steady Magnitude </= 1.0 g



Note: The Non-Isolated Rack Assessment (NIRA) is a prediction of the "vehicle induced", Assembly Complete, acceleration environment at non-isolated ISPRs during microgravity mode. The acceleration environment depicted represents a 100 second, root-mean-square average per one-third octave band from 0.01 to 300 Hz at the rack to module structural interfaces. It is intended to represent the enveloped acceleration response over all the non-isolated ISPR locations in the U.S. Lab, JEM, and APM. The NIRA is based on the DAC–4 ISS assessment of vehicle microgravity compliance which computed the acceleration response to all significant U.S. and Russian segment disturbance sources. To account for the ESA and NASDA disturbance sources, the NIRA at this time assumes that the acceleration responses produced by the ESA and NASDA disturbances are equivalent to the responses produced by the U.S. Lab, Hab, and Airlock disturbances combined less exercise equipment. A similar assumption is also used to account for the CAM in this NIRA. Thus, with these assumptions, the NIRA accounts for all "vehicle induced" accelerations during microgravity mode. The NIRA does not account for "payload induced" accelerations nor "crew induced" accelerations, other than those produced by the crew when using exercise devices. The NIRA is expected to be updated as improved predictions become available.

Figure 13. Assembly complete vibratory environment

f. Components mounted to the ISPR's shall maintain positive margins of safety for the launch and landing conditions in the MPLM. For early design, the acceleration environment defined in Table IX will be used. These load factors will be superseded by load factors obtained though an ISS-performed coupled loads analysis as described in SSP 52005.

Table VI. Crew-induced loads

CREW SYSTEM OR STRUCTURE	TYPE OF LOAD	LOAD	DIRECTION OF LOAD
Levers, Handles, Operating Wheels, Controls	Push or Pull concentrated on most extreme edge	222.6 N (50 lbf), limit	Any direction
Small Knobs	Twist (torsion)	14.9 N–m (11 ft-lbf), limit	Either direction
Exposed Utility Lines (Gas, Fluid, and Vacuum)	Push or Pull	222.6 N (50 lbf)	Any direction
Rack front panels and any other normally exposed equipment	Load distributed over a 4 inch by 4 inch area	556.4 N (125 lbf), limit	Any direction
Legend: ft = feet, m = meter, N = Newton, lbf = pounds force			

Table VII. Random vibration criteria for ISPR post-mounted equipment weighing 100 pounds or less in the MPLM

FREQUENCY	LEVEL
20 Hz	0.005 g^2/Hz
20–70 Hz	+ 5.0 dB/oct
70–200 Hz	0.04 g^2/Hz
200–2000 Hz	–3.9 dB/oct
2000 Hz	0.002 g^2/Hz
Composite	4.4 grms
Note: Criteria is the same for all directions (X,Y,Z)	

Table VIII. Random vibration criteria for ISPR post-mounted equipment weighing more than 100 pounds in the MPLM

FREQUENCY	LEVEL
20 Hz	0.002 g2/Hz
20–70 Hz	+ 4.8 dB/oct
70–200 Hz	0.015 g2/Hz
200–2000 Hz	–3.7 dB/oct
2000 Hz	0.0006 g2/Hz
Composite	2.4 grms
Note: Criteria is the same for all directions (X,Y,Z)	

Table IX. Payload ISPR mounted equipment load factors (equipment frequency 35 Hz)

Liftoff	X	Y	Z
(g)	± 7.7	± 11.6	± 9.9
Landing	**X**	**Y**	**Z**
(g)	± 5.4	± 7.7	± 8.8

Note: Load factors apply concurrently in all possible combinations for each event and are shown in the rack coordinate system defined in SSP 41017, Part 2, paragraph 3.1.3.

3.2.6.4.2 Rack requirements.

a. The CIR shall maintain positive margins of safety for the on orbit depress/repress rates identified in SSP 41002, paragraph 3.1.7.2.1.
b. The CIR and kneebrace shall have a modal frequency in accordance with SSP 52005, paragraph 5.7, second paragraph for launch and landing, based on rigidly mounting the integrated rack in the launch configuration.
c. Equipment mounted directly to the CIR ISPR will have a modal frequency goal of 35 Hz for launch and landing, based on rigidly mounting the component at the component to rack interface.
d. The CIR shall comply with the keep-out zone for rack pivot mechanism as defined in SSP 41017 Part 1, paragraph 3.2.1.1.2.
e. The CIR shall be capable of rotating a minimum of 80 degrees about the pivot point for on orbit installation, removal, and ISS maintenance functions.
f. The CIR and CIR equipment that have Portable Fire Extinguisher (PFE) access ports shall maintain positive margins of safety when exposed to the PFE discharge rate given in Figure 14.
g. The CIR shall use the rack and crew restraints identified in SSP 30257:004 (for example, the 14-in. fixed-length tether and the 71-in. adjustable-length tether) to secure the rack in these rotated positions for payload operations and maintenance.
h. The CIR shall not have a pressure relief device on the front of the rack.
i. The CIR shall be designed in accordance with the requirements specified in SSP 52005.
j. For frequencies below 0.01 Hz, the CIR shall limit unbalanced translational average impulse to generate less than 10 lb-s (44.8 N-s) within any 10 to 500 second period, along any ISS coordinate system vector.
k. Between 0.01 and 300 Hz, the inactive ARIS CIR shall limit vibration so that the limits of Figure 15 are not exceeded using the force method, or the limits of Table XI are not exceeded using the acceleration method.
l. The CIR shall limit force applied to the ISS over any ten second period to an impulse of no greater than 10 lb-s (44.5 N-s). Non-rack payloads shall limit force applied to the ISS over any ten second period to an impulse of no greater than 2.5 lb-s (11.1 N-s).
m. The CIR shall limit their peak force applied to the ISS to less than 1000 lb (4448 N) for any duration. NOTE: Meeting the transient requirements of both l and m does not obviate the need to also meet the 100 second vibration requirement of k for vibration included in and following the transient disturbance.

n. CIR vibration induced by payloads shall not exceed the on-board to off-board vibration force limit of Figure 17 during microgravity periods, considering ARIS suspended rack structural dynamics and control system interaction, while ARIS is actively isolating.

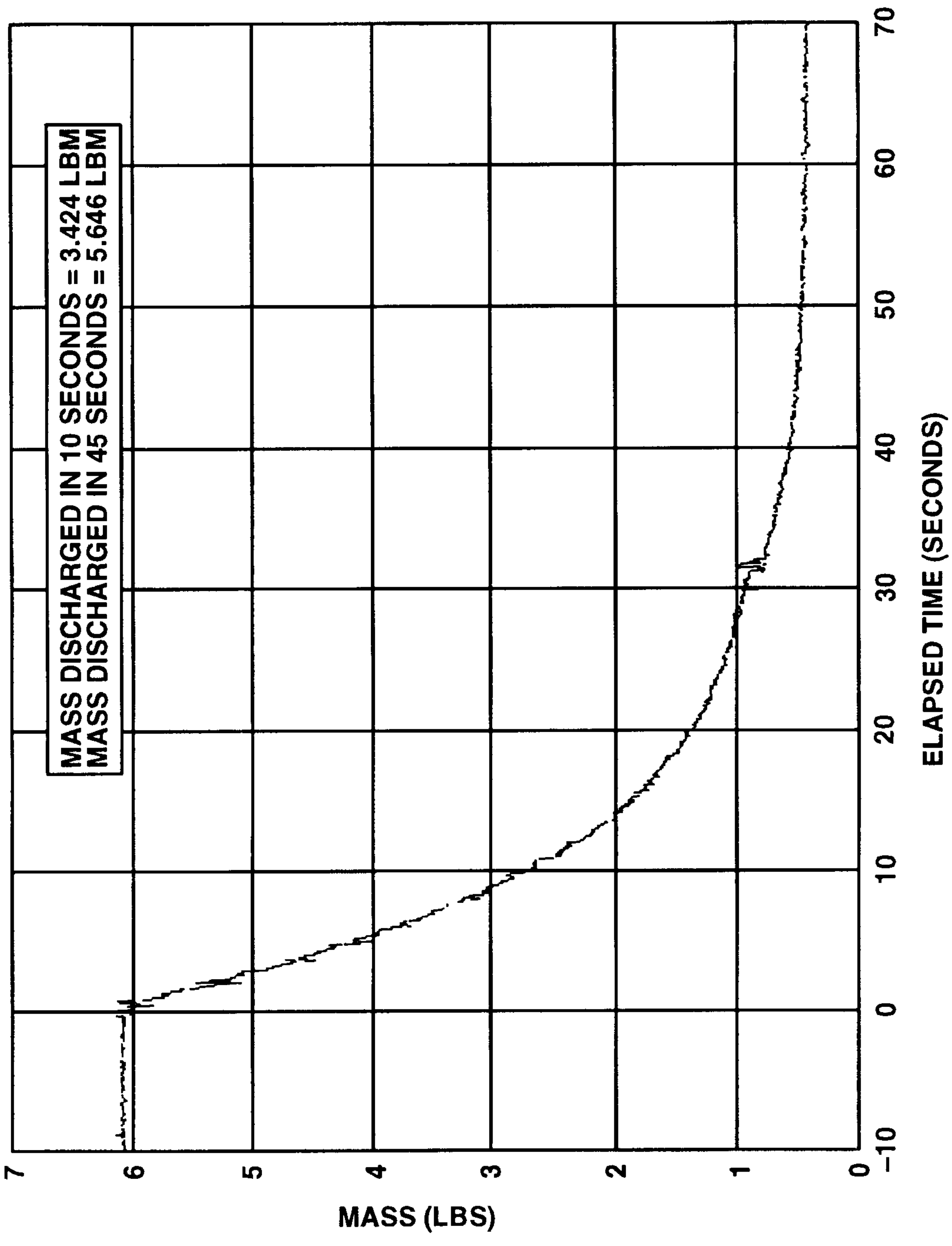


Figure 14. Manual fire suppression system performance characteristics at the rack interface

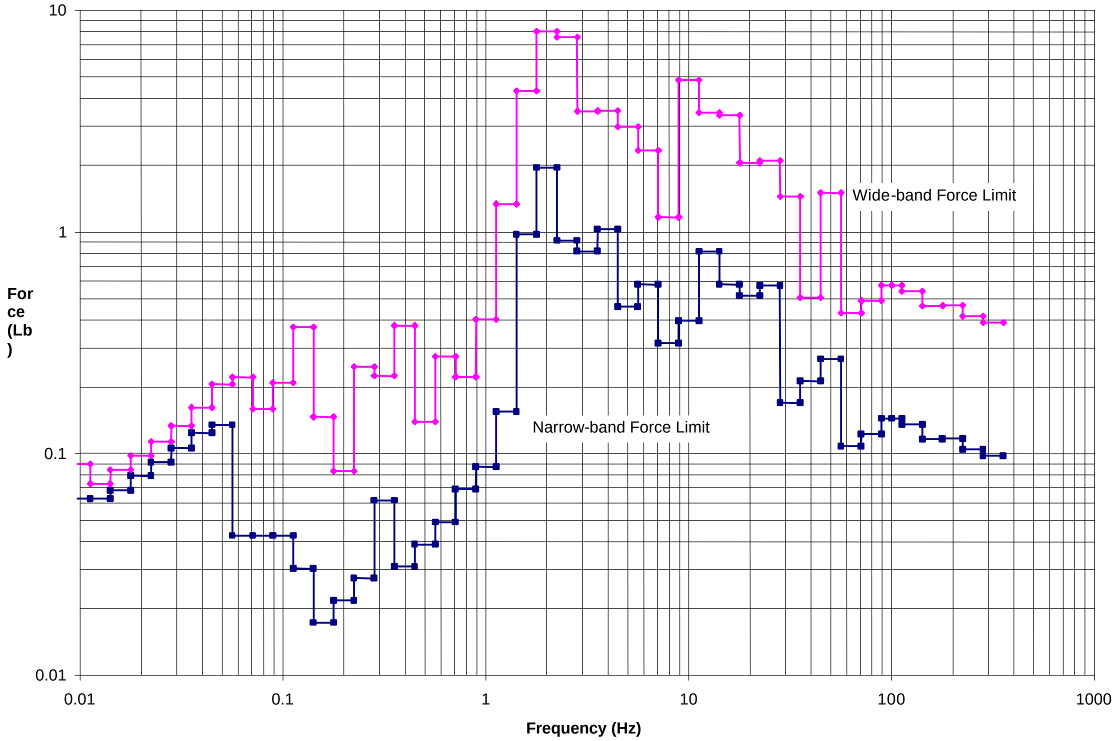


Figure 15. Allowable one-third octave interface forces for integrated racks and non-payloads, 0.5% damping factor

Table X. Allowable integrated rack narrow-band envelope and wideband inteface force values for ISPRs, 0.5% damping factor

Freq (Hz)	NB lb f	WB Lb f
0.008913	0.06261	0.089635
0.01122	0.06261	0.089635
0.01122	0.06261	0.073218
0.01413	0.06261	0.073218
0.01413	0.068172	0.084667
0.01778	0.068172	0.084667
0.01778	0.079202	0.097495
0.02239	0.079202	0.097495
0.02239	0.091377	0.112968
0.02818	0.091377	0.112968
0.02818	0.105641	0.133067
0.03548	0.105641	0.133067
0.03548	0.123739	0.161094
0.04467	0.123739	0.161094
0.04467	0.134457	0.205508
0.05623	0.134457	0.205508
0.05623	0.042699	0.22137
0.07079	0.042699	0.22137
0.07079	0.042699	0.158917
0.08913	0.042699	0.158917
0.08913	0.042699	0.2093
0.1122	0.042699	0.2093
0.1122	0.030213	0.373089
0.1413	0.030213	0.373089
0.1413	0.017289	0.146008
0.1778	0.017289	0.146008
0.1778	0.021755	0.083429
0.2239	0.021755	0.083429
0.2239	0.027396	0.24715
0.2818	0.027396	0.24715
0.2818	0.061482	0.224779
0.3548	0.061482	0.224779
0.3548	0.030924	0.378806
0.4467	0.030924	0.378806
0.4467	0.038934	0.138909
0.5623	0.038934	0.138909
0.5623	0.04901	0.274588
0.7079	0.04901	0.274588
0.7079	0.06922	0.222568
0.8913	0.06922	0.222568
0.8913	0.087153	0.404688
1.122	0.087153	0.404688
1.122	0.154561	1.337042
1.413	0.154561	1.337042
1.413	0.976353	4.322593
1.778	0.976353	4.322593
1.778	1.953413	8.01995
2.239	1.953413	8.01995
2.239	0.915835	7.567684
2.818	0.915835	7.567684
2.818	0.818034	3.504552
3.548	0.818034	3.504552
3.548	1.029953	3.531682
4.467	1.029953	3.531682
4.467	0.460611	2.979207
5.623	0.460611	2.979207
5.623	0.579824	2.330438
7.079	0.579824	2.330438
7.079	0.315606	1.16448
8.913	0.315606	1.16448
8.913	0.39737	4.848007
11.22	0.39737	4.848007
11.22	0.817148	3.451307
14.13	0.817148	3.451307
14.13	0.579786	3.358266
17.78	0.579786	3.358266
17.78	0.516921	2.048448
22.39	0.516921	2.048448
22.39	0.57451	2.091627
28.18	0.57451	2.091627
28.18	0.168996	1.443748
35.48	0.168996	1.443748
35.48	0.212776	0.50643
44.67	0.212776	0.50643
44.67	0.267886	1.498072
56.23	0.267886	1.498072
56.231	0.10793	0.431721
70.79	0.10793	0.431721
70.791	0.122491	0.489965
89.13	0.122491	0.489965
89.131	0.143827	0.575309
100	0.143827	0.575309
112.2	0.143827	0.575309
112.2	0.135367	0.541469
141.3	0.135367	0.541469
141.3	0.115819	0.463274
177.8	0.115819	0.463274
177.8	0.116941	0.467763
223.9	0.116941	0.467763
223.9	0.104363	0.417452
281.8	0.104363	0.417452
281.8	0.097688	0.390751
354.8	0.097688	0.390751

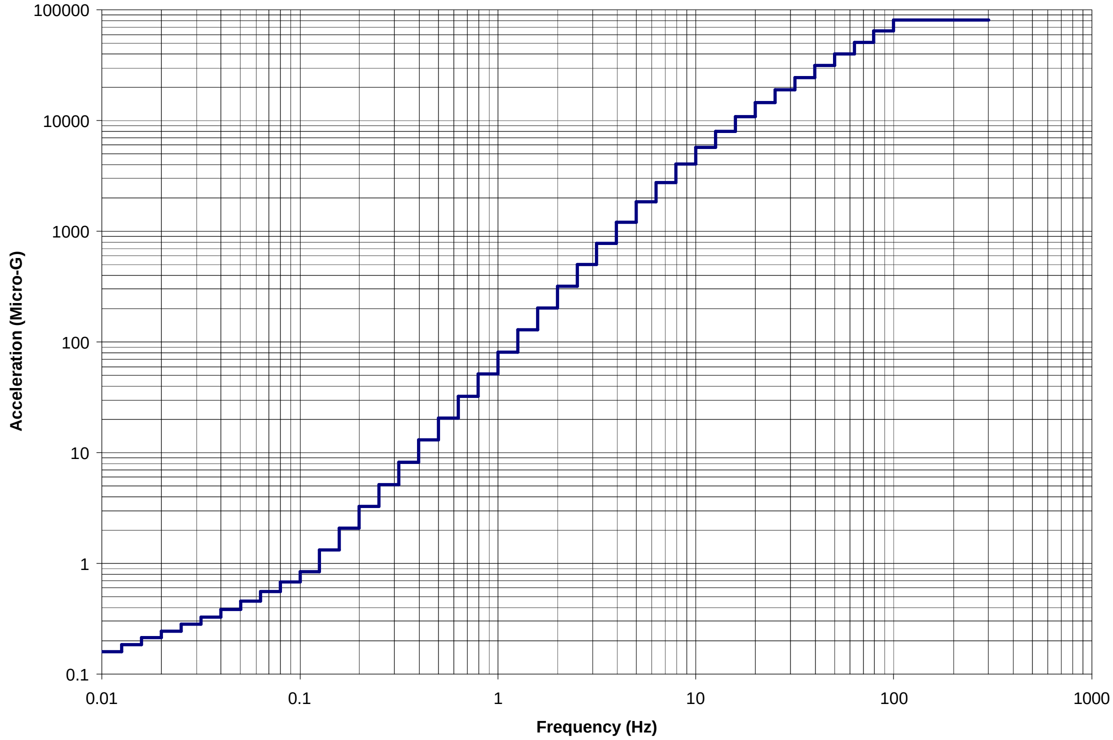


Figure 16. Non-ARIS-to ARIS acceleration limit alternative to force limits

Table XI. Non-ARIS integrated rack to ARIS acceleration limit alternative to force limits

Freq	Accel Limit (ug)	Freq	Accel Limit (ug)	Freq	Accel Limit (ug)
0.0089	0.159	0.226	5.18	5.74	2746
0.0112	0.159	0.285	5.18	7.23	2746
0.0112	0.185	0.285	8.19	7.23	4026
0.0141	0.185	0.359	8.19	9.11	4026
0.0141	0.213	0.359	12.97	9.11	5758
0.0178	0.213	0.452	12.97	11.48	5758
0.0178	0.244	0.452	20.53	11.48	8021
0.0224	0.244	0.570	20.53	14.47	8021
0.0224	0.281	0.570	32.49	14.47	10898
0.0283	0.281	0.718	32.49	18.23	10898
0.0283	0.325	0.718	51.42	18.23	14495
0.0356	0.325	0.904	51.42	22.96	14495
0.0356	0.383	0.904	81.33	22.96	18956
0.0449	0.383	1.139	81.33	28.93	18956
0.0449	0.458	1.139	128.51	28.93	24483
0.0565	0.458	1.435	128.51	36.45	24483
0.0565	0.556	1.435	202.73	36.45	31346
0.0712	0.556	1.808	202.73	45.93	31346
0.0712	0.682	1.808	318.99	45.93	39894
0.0897	0.682	2.278	318.99	57.87	39894
0.0897	0.843	2.278	499.90	57.87	50578
0.1130	0.843	2.871	499.90	72.91	50578
0.1130	1.322	2.871	778.69	72.91	63958
0.1424	1.322	3.617	778.69	91.86	63958
0.1424	2.079	3.617	1202.18	91.86	80751
0.1794	2.079	4.557	1202.18	100.00	80751
0.1794	3.280	4.557	1832.55	300.00	80751
0.2260	3.280	5.741	1832.55		

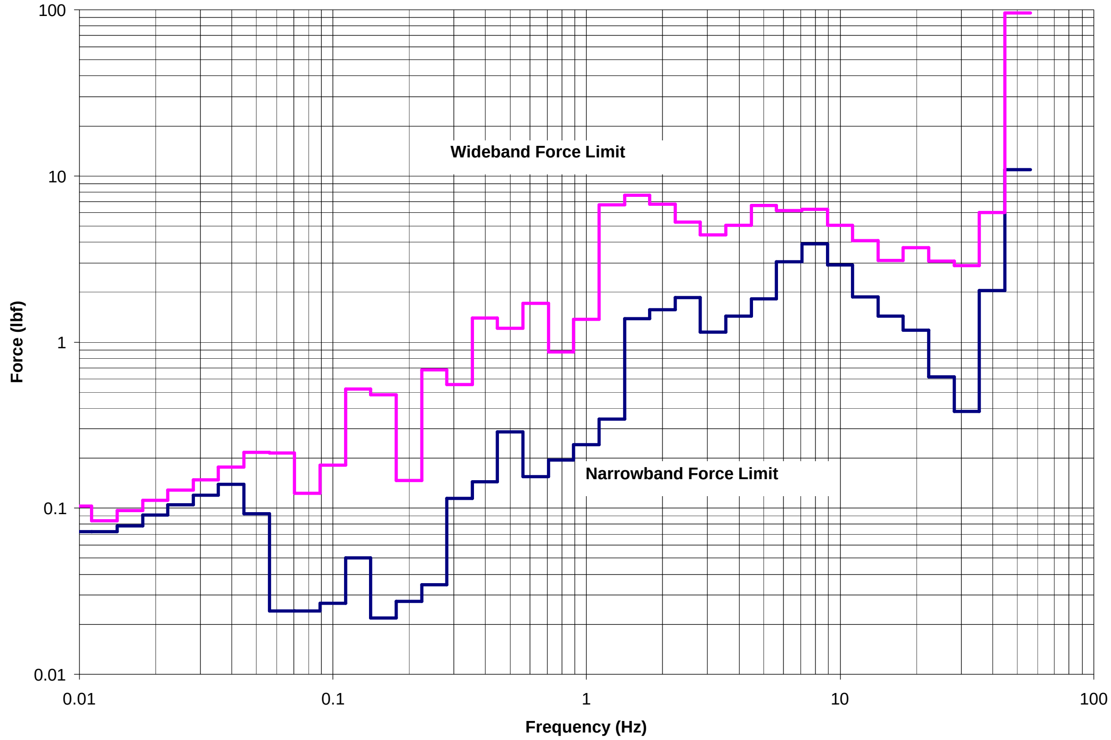


Figure 17. Allowable on-board force values for ARIS integrated payloads to meet off-board limits

Table XII. Allowable on-board force values for ARIS integrated payloads to meet off-board limits

Freq. (Hz.)	NBP Limit (lbf)	WB Limit (lbf)	Freq. (Hz.)	NBP Limit (lbf)	WB Limit (lbf)	Freq. (Hz.)	NBP Limit (lbf)	WB Limit (lbf)
0.0089	0.0722	0.1033	0.1778	0.0274	0.1466	3.5480	1.4337	5.0388
0.0112	0.0722	0.1033	0.2239	0.0274	0.1466	4.4670	1.4337	5.0388
0.0112	0.0722	0.0842	0.2239	0.0346	0.6819	4.4670	1.8234	6.6213
0.0141	0.0722	0.0842	0.2818	0.0346	0.6819	5.6230	1.8234	6.6213
0.0141	0.0785	0.0971	0.2818	0.1147	0.5577	5.6230	3.0271	6.2002
0.0178	0.0785	0.0971	0.3548	0.1147	0.5577	7.0790	3.0271	6.2002
0.0178	0.0910	0.1113	0.3548	0.1445	1.3967	7.0790	3.8832	6.2891
0.0224	0.0910	0.1113	0.4467	0.1445	1.3967	8.9130	3.8832	6.2891
0.0224	0.1046	0.1279	0.4467	0.2881	1.2088	8.9130	2.9020	5.0388
0.0282	0.1046	0.1279	0.5623	0.2881	1.2088	11.2200	2.9020	5.0388
0.0282	0.1201	0.1488	0.5623	0.1554	1.7174	11.2200	1.8602	4.0770
0.0355	0.1201	0.1488	0.7079	0.1554	1.7174	14.1300	1.8602	4.0770
0.0355	0.1392	0.1763	0.7079	0.1945	0.8709	14.1300	1.4350	3.0919
0.0447	0.1392	0.1763	0.8913	0.1945	0.8709	17.7800	1.4350	3.0919
0.0447	0.0926	0.2167	0.8913	0.2416	1.3743	17.7800	1.1754	3.7060
0.0562	0.0926	0.2167	1.1220	0.2416	1.3743	22.3900	1.1754	3.7060
0.0562	0.0240	0.2147	1.1220	0.3449	6.7131	22.3900	0.6179	3.0764
0.0708	0.0240	0.2147	1.4130	0.3449	6.7131	28.1800	0.6179	3.0764
0.0708	0.0240	0.1225	1.4130	1.3847	7.6318	28.1800	0.3821	2.9013
0.0891	0.0240	0.1225	1.7780	1.3847	7.6318	35.4800	0.3821	2.9013
0.0891	0.0269	0.1820	1.7780	1.5667	6.7883	35.4800	2.0342	6.0143
0.1122	0.0269	0.1820	2.2390	1.5667	6.7883	44.6700	2.0342	6.0143
0.1122	0.0502	0.5226	2.2390	1.8464	5.2891	44.6700	10.9057	96.2593
0.1413	0.0502	0.5226	2.8180	1.8464	5.2891	56.2300	10.9057	96.2593
0.1413	0.0218	0.4830	2.8180	1.1511	4.4228			
0.1778	0.0218	0.4830	3.5480	1.1511	4.4228			

3.2.6.4.3 Electrical requirements.

3.2.6.4.3.1 Steady-state voltage characteristics.

The CIR at Interface B shall operate and be compatible with the steady-state voltage limits of 116 to 126 Vdc.

3.2.6.4.3.2 Ripple voltage characteristics.

a. The CIR Electrical Power Consuming Equipment (EPCE) connected to Interface B shall operate and be compatible with the Electrical Power System (EPS) time domain ripple voltage and noise level of at least 2.5 Vrms within the frequency range of 30 Hz to 10 kHz.
b. The CIR EPCE connected to Interface B shall operate and be compatible with the EPS Ripple Voltage Spectrum as shown in Figure 18.
   Note: This limit is 6 dB below the electromagnetic compatibility (EMC) CS-01, CS–02 requirement in SSP 30237 up to 30 MHz.

3.2.6.4.3.3 Transient voltages.

The CIR at Interface B shall operate and be compatible with the limits of magnitude and duration for the voltage transients at Interface B as shown in Figure 19.

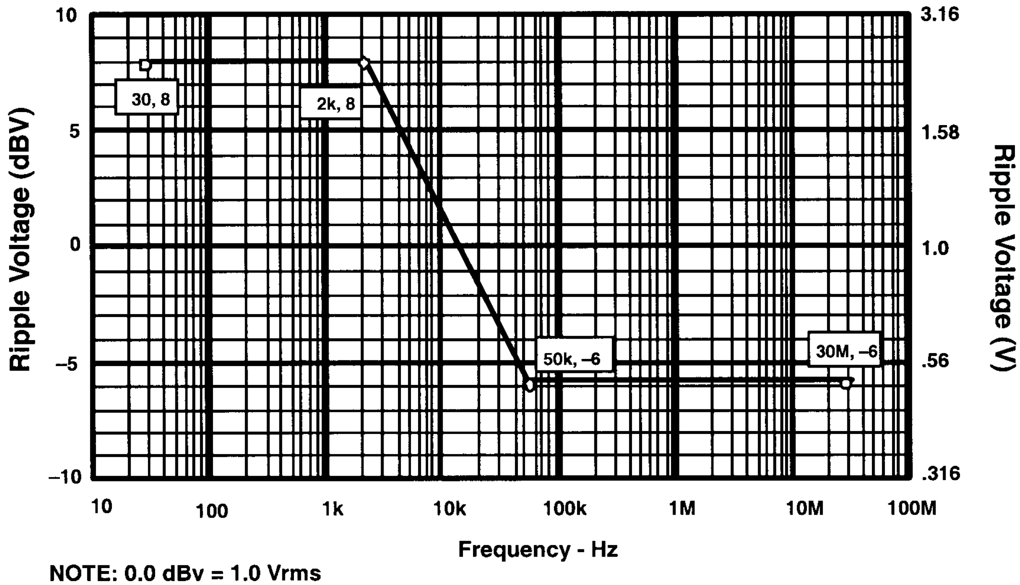


Figure 18. Maximum Interfaces B and C ripple voltage spectrum

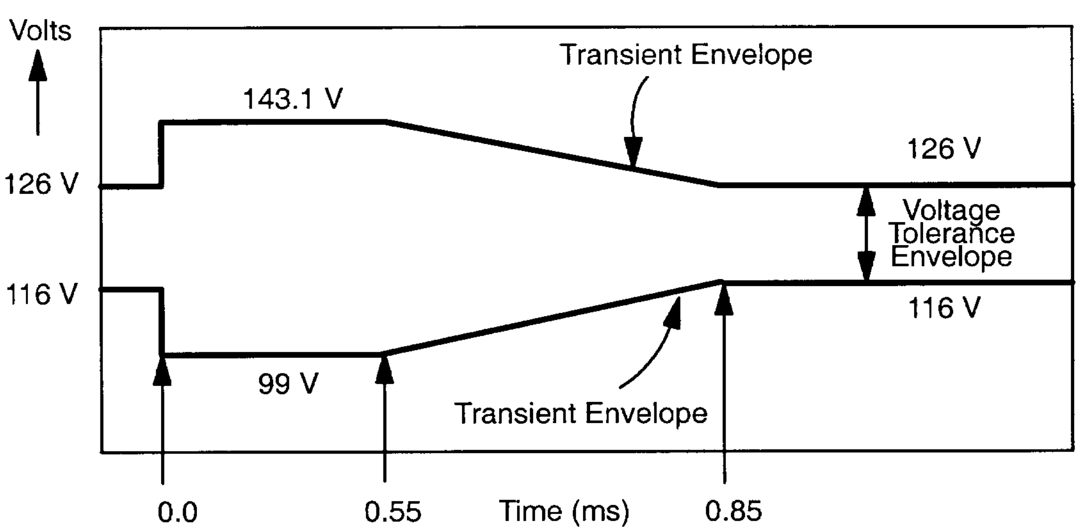


Figure 19. Interface B voltage transients

The envelope shown in this figure applies to the transient responses exclusive of any periodic ripple or noise components that may be present.

3.2.6.4.3.4 Fault clearing and protection.

The CIR EPCE connected to Interface B shall be safe and not suffer damage with the transient voltage conditions that are within the limits shown in Figure 20. Loads may be exposed to transient overvoltage conditions during operation of the power system's fault protection components.

3.2.6.4.3.5 Non-normal voltage range.

The CIR EPCE connected to Interface B shall not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware with non-normal voltage characteristics of a maximum overvoltage of + 165 Vdc for 10 s and undervoltage conditions of +102 Vdc for an indefinite period of time.

3.2.6.4.3.6 Power bus isolation.

a. The CIR shall provide a minimum of 1-MΩ isolation in parallel with not more than 0.03 μF of mutual capacitance within internal and external rack EPCE at all times such that no single failure shall cause the independent power buses to be electrically tied. (Mutual capacitance is defined as line-to-line capacitance, exclusive of the EMI input filter.)
b. CIR internal and external CIR shall not use diodes to electrically tie together independent ISS power bus high side or return lines. These requirements apply to both supply and return lines. ISS provides the capability to support simultaneous use of Main (J1) and Auxiliary (J2) power at each ISPR location (except MPLM). Constrained element level payload operations may occur from individual payload racks which automatically switch to or require simultaneous use of auxiliary power.

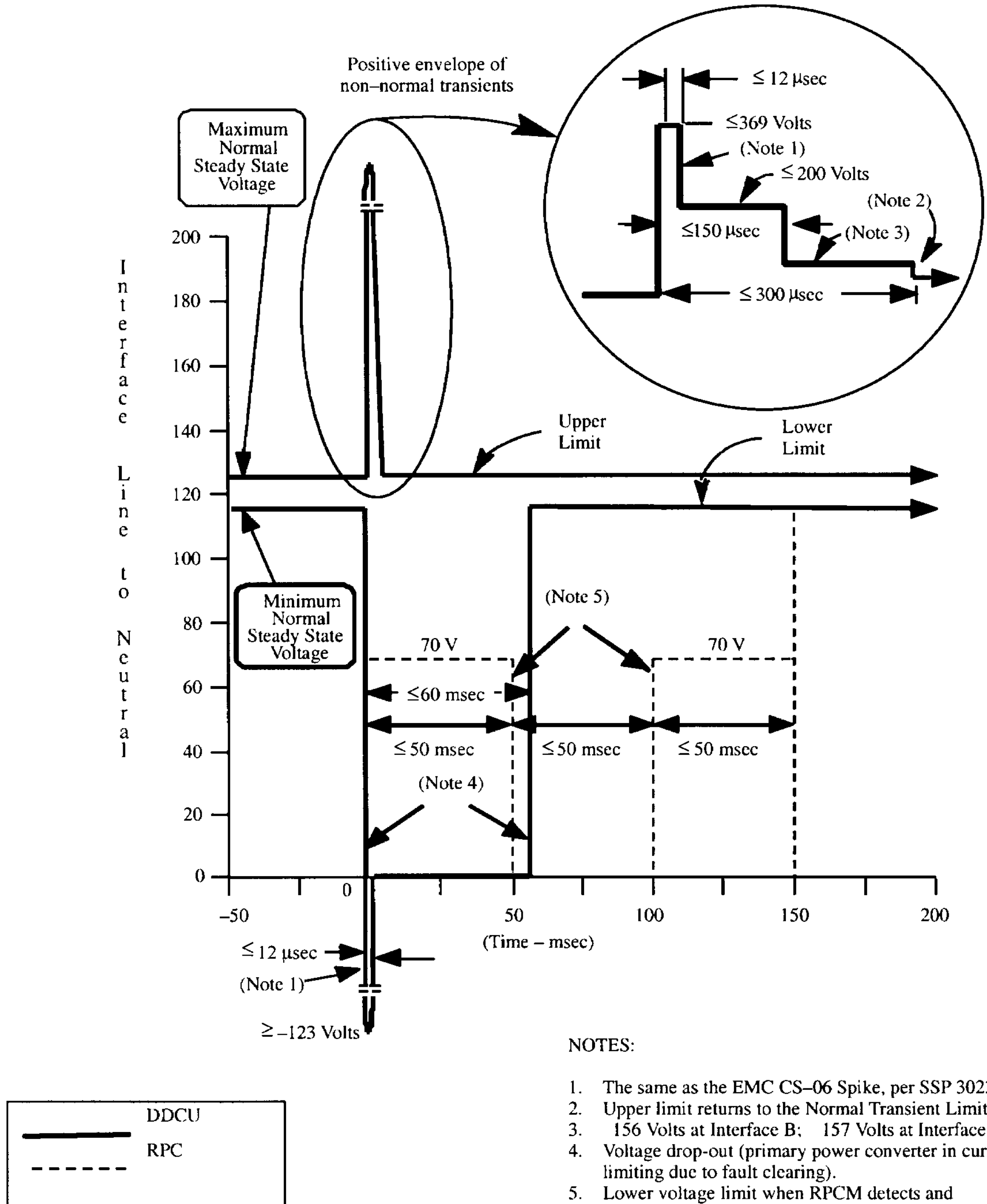
3.2.6.4.3.7 Compatibility with soft start/stop remote power controller (RPC).

The CIR EPCE connected to the Interface B shall initialize with the soft start/stop performance characteristics when power is applied, sustained, and removed by control of remote power control switches as specified in Figure 21.

3.2.6.4.3.8 Surge current.

The CIR EPCE connected to Interface B electrical interface surge current at the power inputs shall not exceed the surge current values defined in Figure 22 and Figure 23 when powered from a voltage source with characteristics specified in SSP 57000, paragraphs 3.2.1 and 3.2.2.3, with the exception that the source impedance is considered to be 0.1 Ω. The duration of the surge current shall not exceed 10 ms. These requirements apply to all operating modes and changes including power-up and power-down.

c.



NOTES:

1. The same as the EMC CS–06 Spike, per SSP 30237.
2. Upper limit returns to the Normal Transient Limit.
3. 156 Volts at Interface B; 157 Volts at Interface C.
4. Voltage drop-out (primary power converter in current limiting due to fault clearing).
5. Lower voltage limit when RPCM detects and responds to under voltage conditions.

Figure 20. Fault clearing and protection transient limits

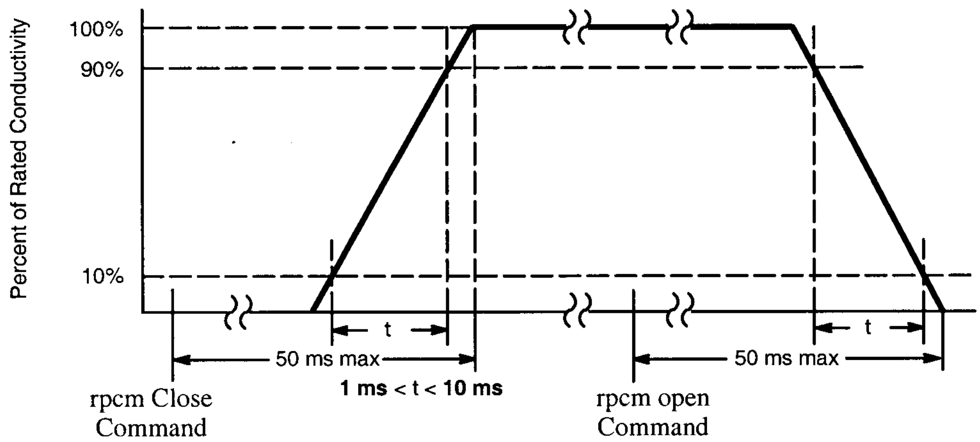


Figure 21. U.S. RPCM soft start/stop characteristics

3.2.6.4.3.9 Reverse energy/current.

The CIR electrical interface main input power and Auxiliary input power shall comply with the requirements defined in Table XXII for the reverse energy/current into the upstream power source. The CIR interface shall meet either the reverse energy or the reverse current requirement for all environmental conditions specified in this document when powered from a voltage source with characteristics specified in SSP 57000, paragraphs 3.2.1 and 3.2.2.3 with a source impedance of 0.1 Ω.

3.2.6.4.3.10 Current protection devices.

a. The CIR shall operate and be compatible with the characteristics in Figures 3.2.6–2, 3.2.6–3, and 3.2.6–4 as described in paragraph 3.2.6 located in SSP 57001.
b. Overcurrent protection shall be provided at all points in the system where power is distributed to lower level (wire size not protected by upstream circuit protection device) feeder and branch lines.
c. The CIR shall provide current limiting overcurrent protection for all internal loads (exclusive of overcurrent protection circuits and devices) drawing power from an Interface B power feed. For the purpose of this requirement, internal overcurrent protection circuits and devices are not considered to be loads.

3.2.6.4.3.11 CIR trip ratings.

The payload power circuit protection device in the CIR connected to Interface B shall be designed to provide trip coordination, (i.e., the downstream circuit protection device disconnects a shorted circuit or an overloaded circuit from the upstream power interface without tripping the upstream circuit protection device). The trip coordination is achieved either by shorter trip time or lower current limitation than the upstream protection devices defined in paragraph 3.2.6.4.3.10 a.

3.2.6.4.3.12 Interface B complex load impedances.

a. The load impedance presented by the CIR to the Main Interface B shall not exceed the bounds defined by Figure 24 and Figure 25 for input over the frequency range of 50 Hz to 100 kHz. The magnitude component of the CIR input impedance should not be less than the minimum defined in Figure 24 and Figure 25. At frequencies where the magnitude component of the CIR input impedance is less than the defined minimum, the phase component of the input impedance shall not exceed the bounds defined in Figure 24 and Figure 25.
b. The load impedance presented by the CIR to the 1.2 to 1.44 kW Interface B shall not exceed the bounds defined by Figure 26 for input over the frequency range of 50 Hz to 100 kHz. The magnitude component of the CIR input impedance should not be less than the minimum defined in Figure 26. At frequencies where the magnitude component of the CIR input impedance is less than the defined minimum, the phase component of the input impedance shall not exceed the bounds defined in Figure 26.

3.2.6.4.3.13 Large signal stability.

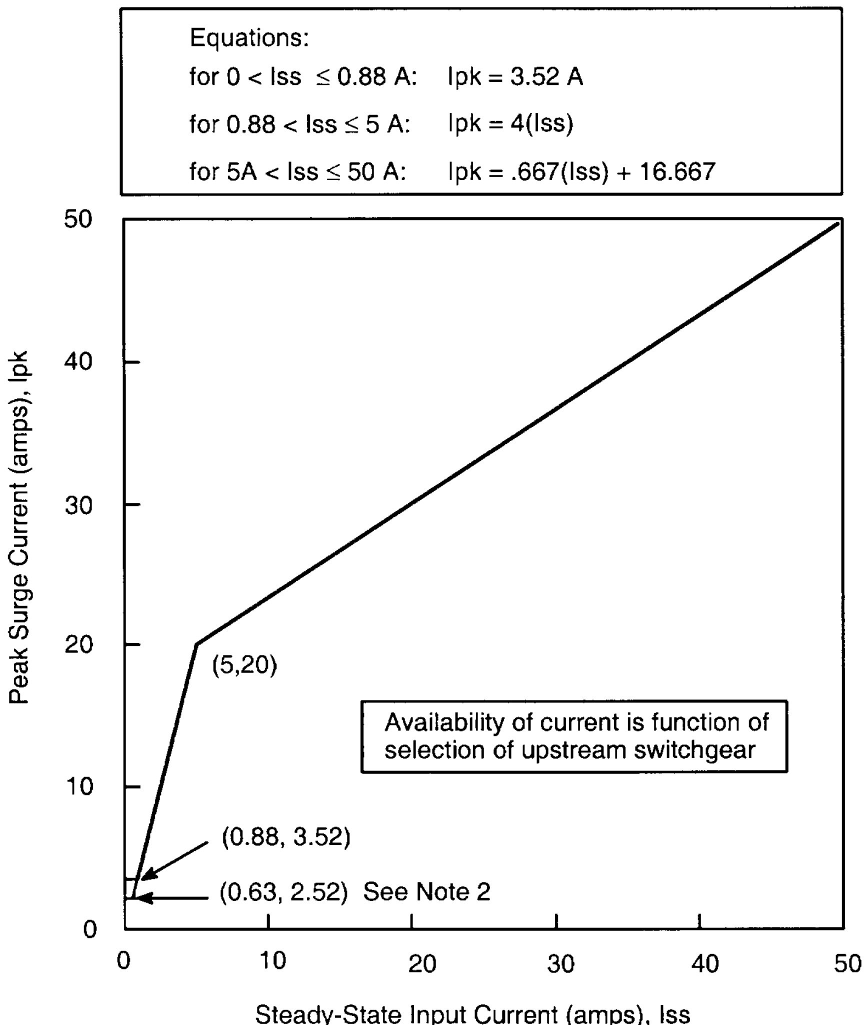
The CIR EPCE connected to Interface B shall maintain stability with the ISS EPS interface by damping a transient response to 10% of the maximum response amplitude within 1.0 ms, and remaining below 10% thereafter under the following conditions:

1. The rise time/fall time (between 10 and 90% of the amplitude) of the input voltage pulse is less than 10 μs.
   e. The voltage pulse is to be varied from 100 to 150 μs in duration.

Note: Figure 27 is used to clarify the above requirement.

3.2.6.4.3.14 Maximum ripple voltage emissions.

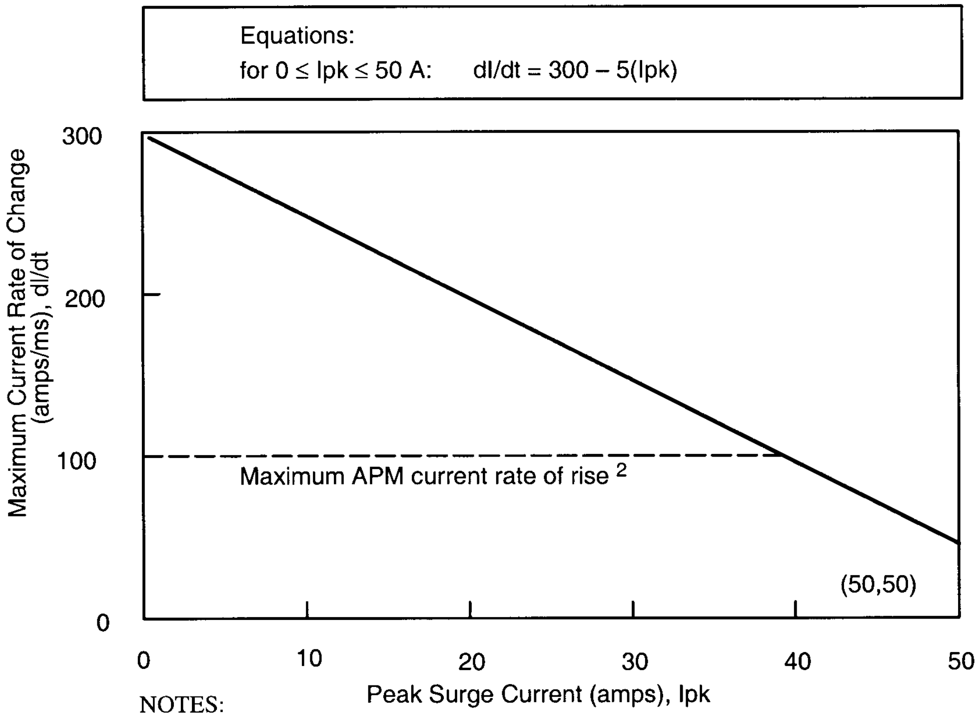
The maximum ripple voltage induced on the power line by the CIR EPCE connected to Interface B shall be no greater than 0.5 V peak-to-peak.



NOTES:

1. For transients less than 100 microseconds, refer to SSP 30237.
2. NASA Space Station equipment accommodated in JEM will have a maximum allowable peak surge current of 2.52 amps for equipment having a steady-state input no greater than 0.63 amps.

Figure 22. Peak surge current amplitude versus steady-state input current



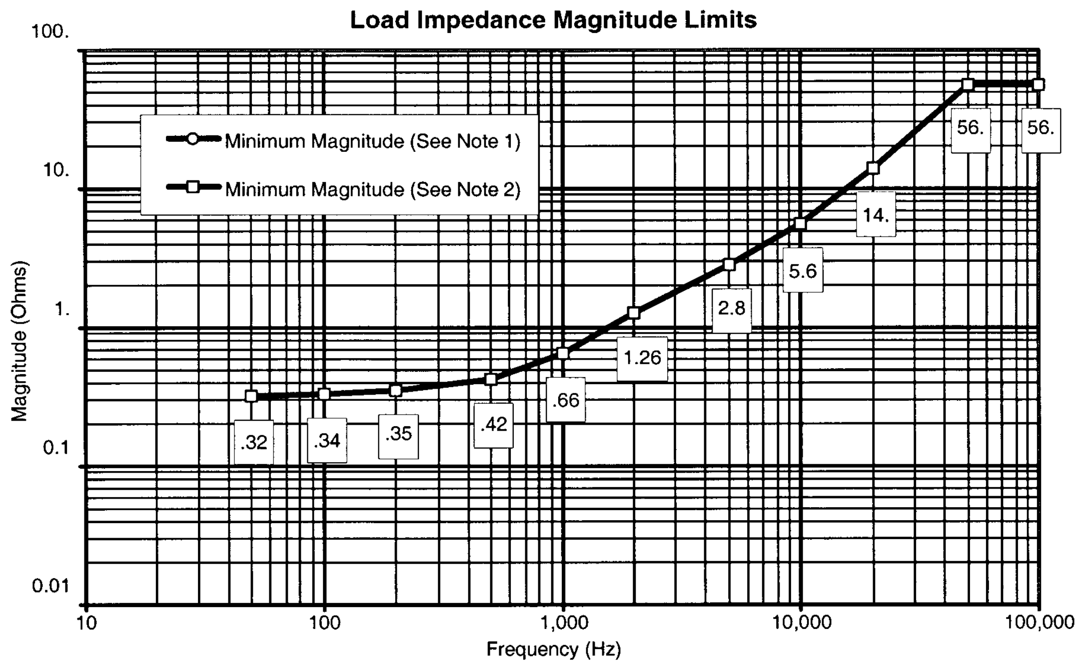
NOTES:

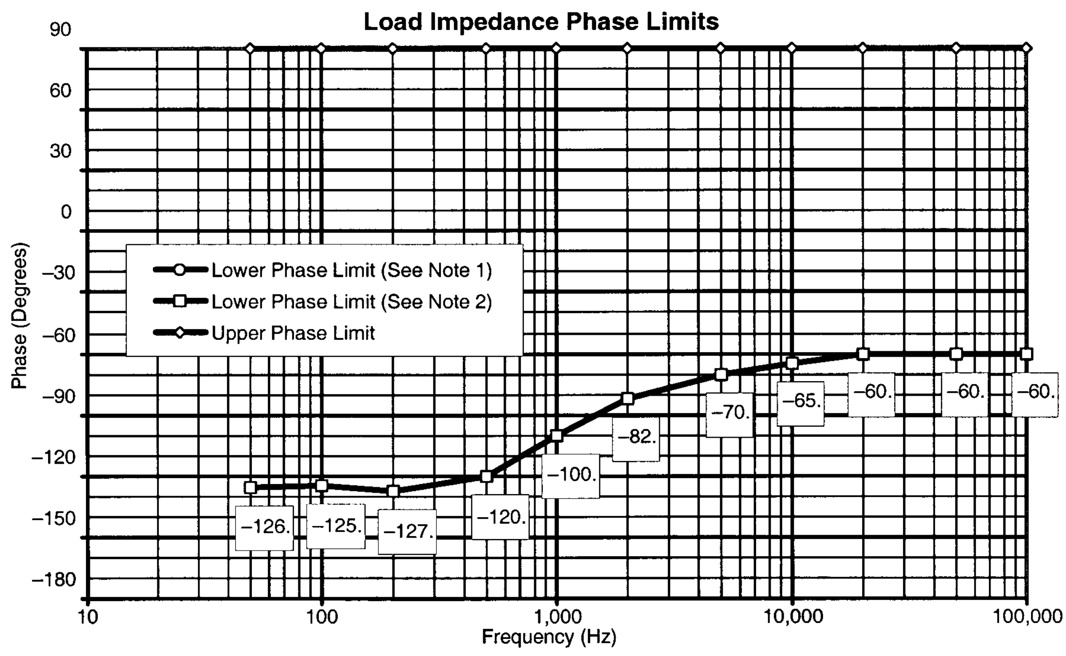
1. For transients less than 100 microseconds, refer to SSP 30237.
2. NASA Space Station and ISPR payload equipment accommodated in APM shall function correctly with a maximum current rate of rise of 100 amps/ms up to 40-amps peak surge current.

Figure 23. Maximum current rate of change versus peak surge current amplitude

Table XIII. Maximum reverse energy/current from downstream loads

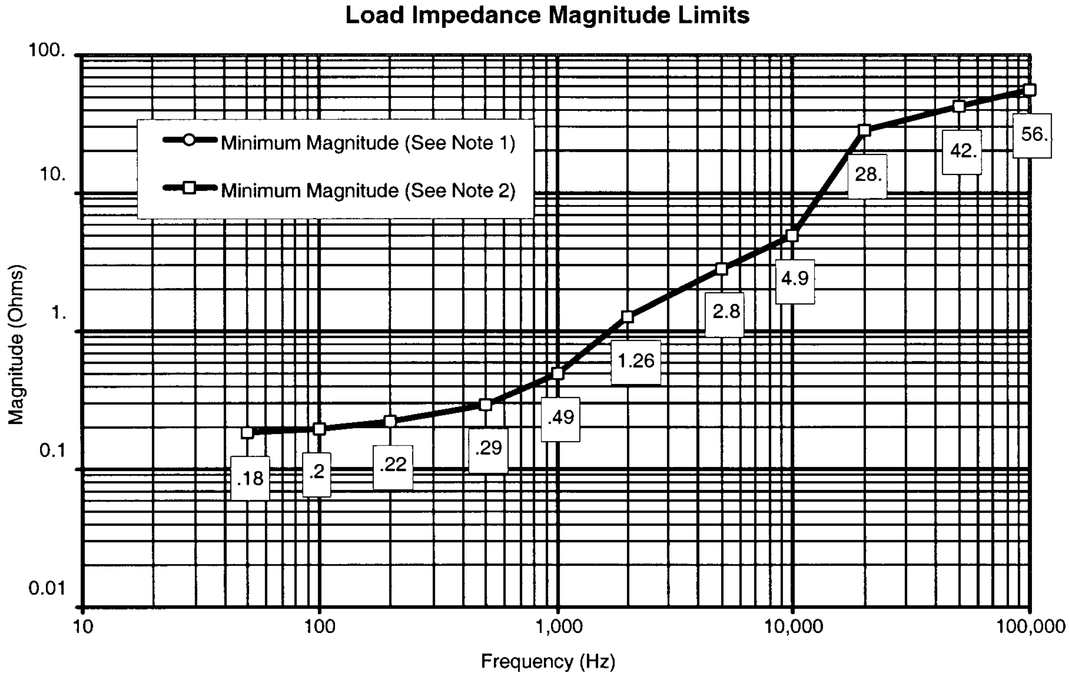
ISPR INTERFACE Power/RPCM type	MAXIMUM REVERSE ENERGY (Joules)	MAXIMUM REVERSE CURRENT (amps)		
		Pulse t < 10 µs	Peak t < 1 ms	Steady State t > 1 s
3 kW / type VI	3.0	400	250	3
6 kW / type III	6.0	800	500	6
JEM	**(TBD #7)**	**(TBD #7)**	**(TBD #7)**	**(TBD #7)**
ESA	**(TBD #8)**	**(TBD #8)**	**(TBD #8)**	**(TBD #8)**
UOP Type I	1.5	400	250	2
UOP Type V	1.5	400	250	2
µs = microseconds ms = milliseconds s = second				

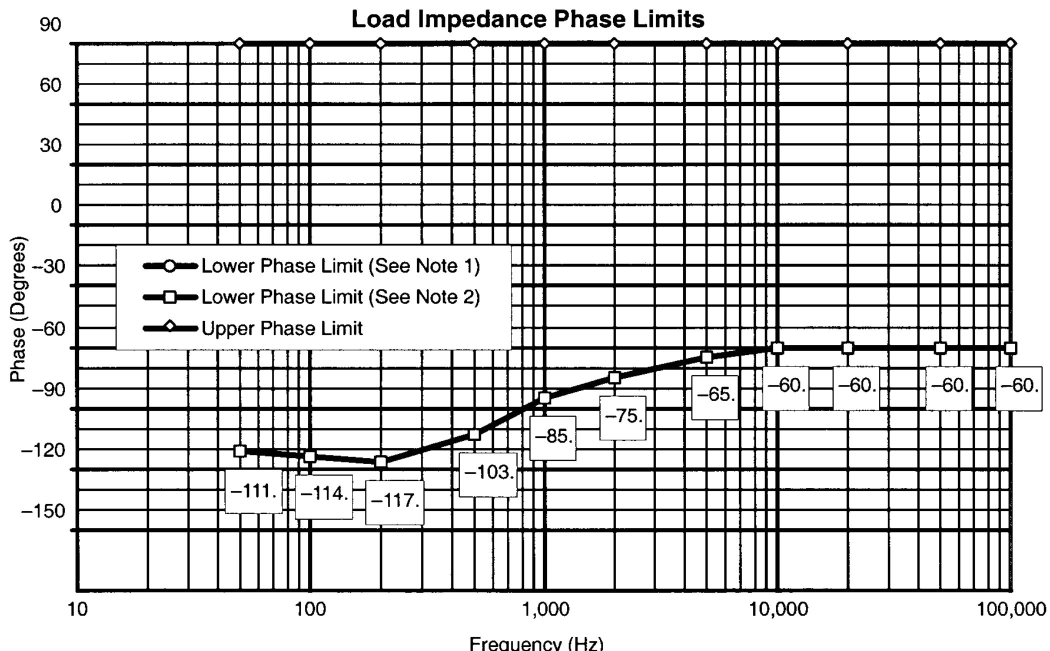




Notes:
1. Limit when total load on the Secondary Power Source is less than 400 watts.
2. Limit when total load on the Secondary Power Source is at least 400 watts.

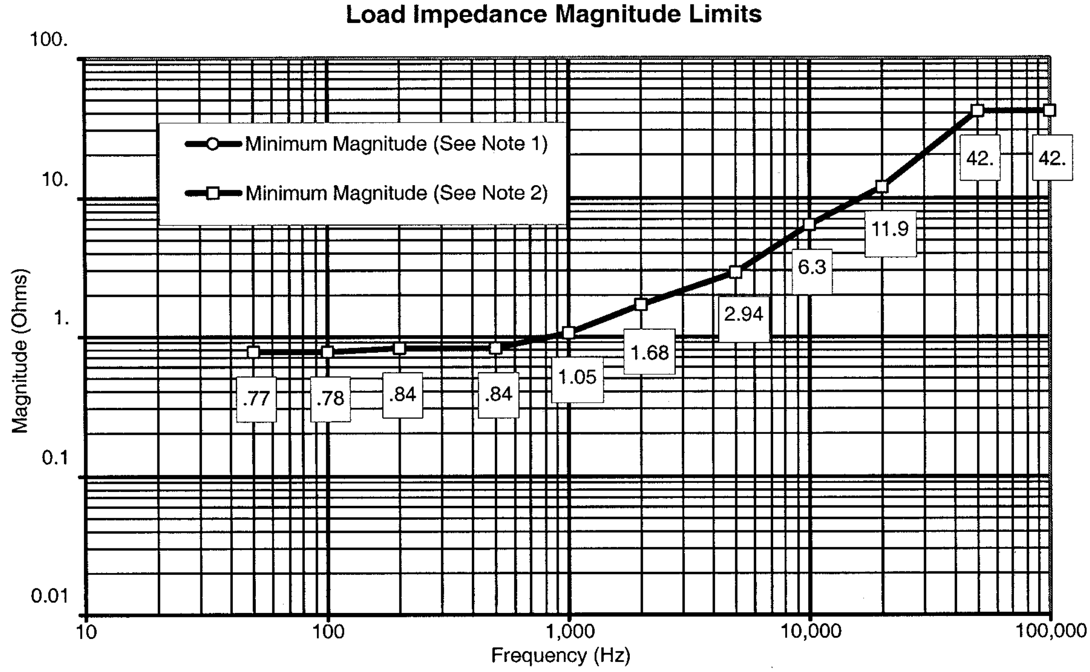
Figure 24. Interface B load impedance limits

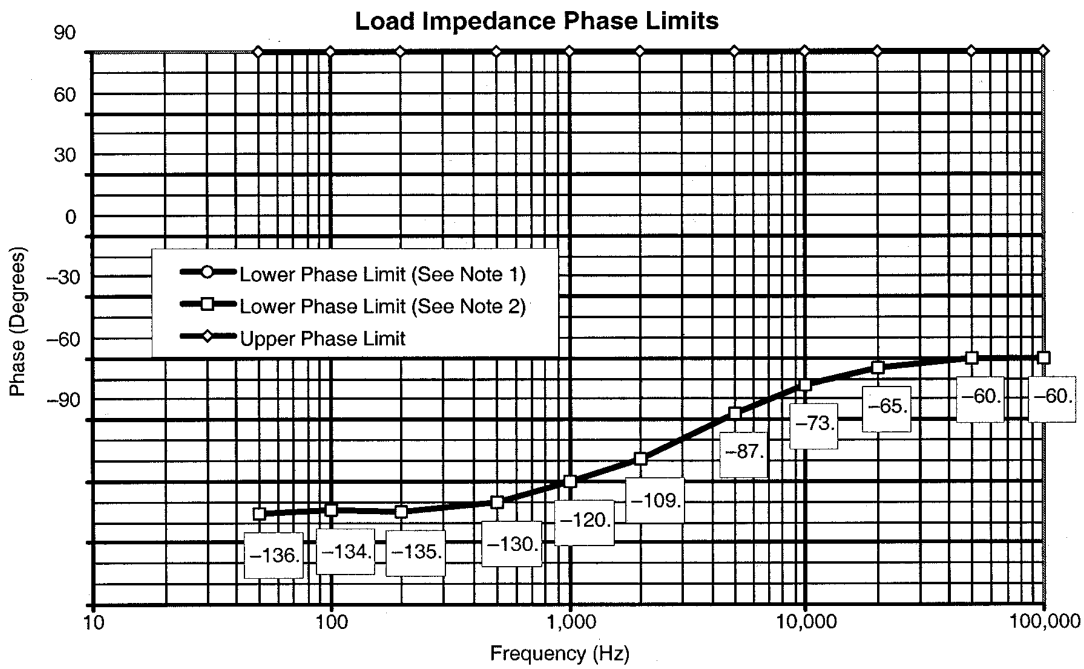




Notes:
1. Limit when total load on the Secondary Power Source is less than 400 watts.
2. Limit when total load on the Secondary Power Source is at least 400 watts.

Figure 25. 6 kw Interface B load impedance limits





Notes:
1. Limit when total load on the Secondary Power Source is less than 400 watts.
2. Limit when total load on the Secondary Power Source is at least 400 watts.

Figure 26. 1.2 to 1.44 kw auxiliary Inteface B load impedance limits

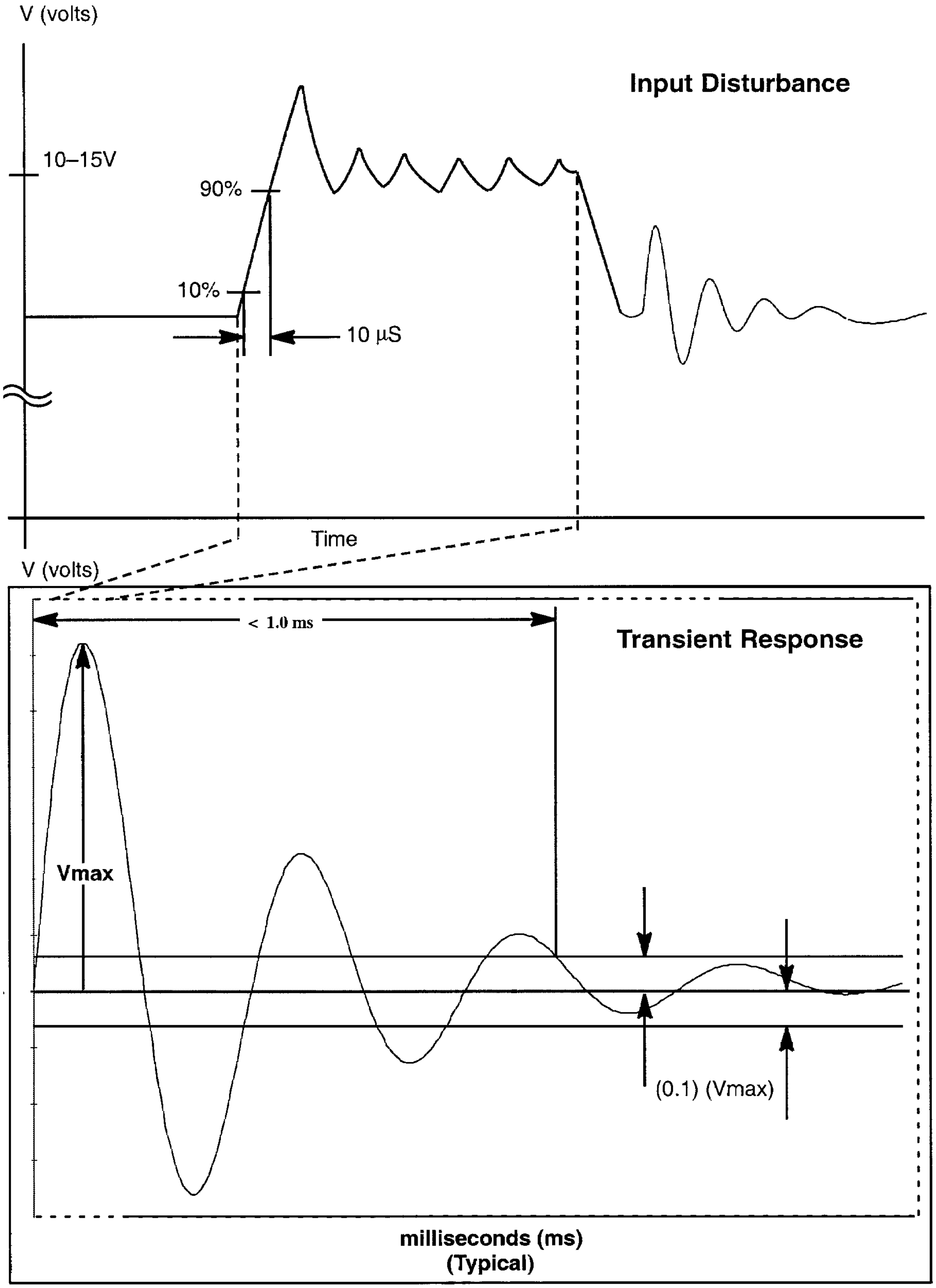


Figure 27. Pulse applied to the power input of the CIR

3.2.6.4.3.15 Wire derating.

a. Derating criteria for EPCE at and downstream of the primary circuit protection device(s) in the CIR, as shown in Figure 28, shall be per NASA Technical Memo (TM) 102179 as interpreted by NSTS 18798, TA-92-038.
b. The CIR shall use 4 gauge wire for main and auxiliary connections at the UIP.

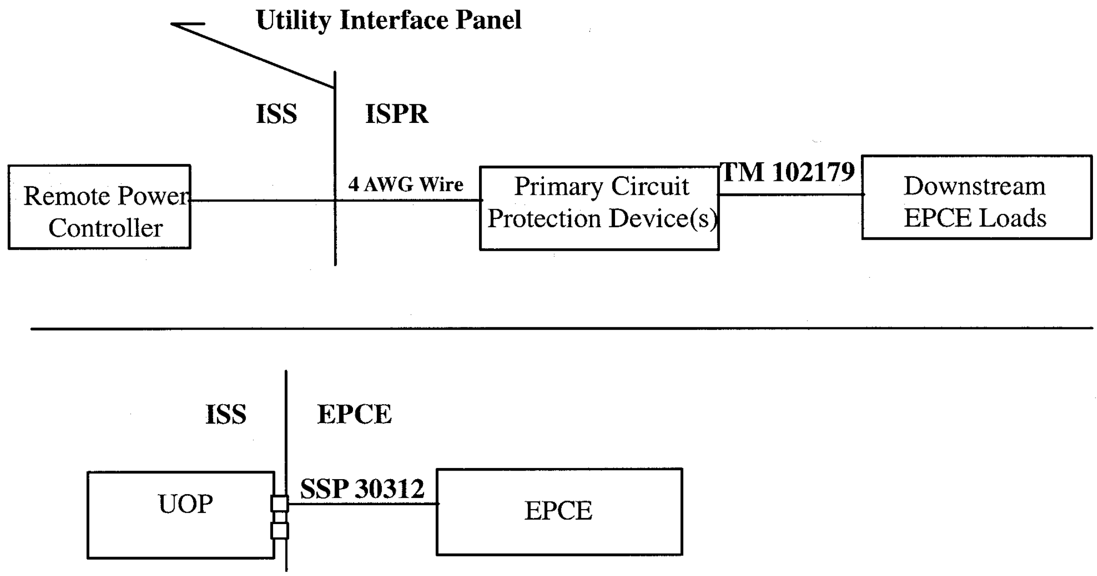


Figure 28. Wire derating requirements for CIR

3.2.6.4.3.16 Exclusive power feeds.

a. The CIR shall receive power only from the UIP dedicated to its rack location.
b. Cabling shall not occur between Interface C connected EPCE with Interface B; and/or Interface B connected EPCE with Interface C.

3.2.6.4.3.17 Loss of power.

The CIR shall fail safe in the event of a total or partial loss of power regardless of the availability of Auxiliary power in accordance with NSTS 1700.7, ISS Addendum.

3.2.6.4.3.18 Electromagnetic compatibility.

The CIR EPCE connected to Interface B shall meet the EMC requirements of SSP 30243, paragraphs 3.1 and 3.6.2.

3.2.6.4.3.18.1 Electrical grounding.

The CIR EPCE connected to Interface B shall meet all requirements specified in section 3 of SSP 30240.

3.2.6.4.3.18.2 Electrical bonding.

The CIR shall interface with the module bond strap per SSP 57001 Hardware ICD Template. Electrical bonding of EPCE connected to Interface B shall be in accordance with SSP 30245 and NSTS 1700.7 ISS Addendum, sections 213 and 220.

3.2.6.4.3.18.3 Cable/wire design and control requirements.

Cabling between CIR EPCE and Interface B shall meet all Cable and Wire Design requirements of SSP 30242.

3.2.6.4.3.18.4 Electromagnetic interference.

The CIR shall meet the requirements as specified in SSP 30237.

3.2.6.4.3.18.5 Electrostatic discharge.

The unpowered CIR and its components shall not be damaged by electrostatic discharge (ESD) equal to or less than 4,000 V to the case or any pin on external connectors. EPCE that may be damaged by ESD between 4,000 and 15,000 V shall have a label affixed to the case in a location clearly visible in the installed position.

3.2.6.4.3.18.6 Alternating current (ac) magnetic fields.

The generated ac magnetic fields, measured at a distance of 7 cm from the generating equipment, shall not exceed 140 dB above 1 pT for frequencies ranging from 30 Hz to 2 kHz, then falling 40 dB per decade to 50 kHz.

3.2.6.4.3.18.7 Direct current (dc) magnetic fields.

The generated dc magnetic fields shall not exceed 170 dB pT at a distance of 7 cm from the generating equipment. This applies to electromagnetic and permanent magnetic devices.

3.2.6.4.3.18.8 Corona.

Electrical and electronic subsystems, equipment, and systems shall be designed to preclude damaging or destructive corona in its operating environment. Guidance for meeting the corona requirement is found in MSFC–STD–531, High Voltage Design Criteria.

3.2.6.4.3.18.9 Lightning.

The CIR EPCE shall meet the lightning induced environment requirement in paragraph 3.2.8.1 of SSP 30243.

3.2.6.4.3.18.10 EMI susceptibility for safety-critical circuits.

Payload safety-critical circuits, as defined in SSP 30243, shall meet the margins defined in SSP 30243, paragraph 3.2.3.

3.2.7 Transportability.

The CIR shall be designed to be transportable within the United States without damage by truck or air via common commercial carrier when packaged as specified herein without requiring special accommodation to meet the transportation and handling limit load factors as specified in Table XIV.

Table XIV. Transportation and handling limit load factors

Mode	Load Occurrence	Fore/Aft g's	Lateral g's	Vertical g's
Air	I	±3.5	±2.0	+3.5/0.0
Truck/air ride trailer	I	±3.5	±2.0	+3.5/-1.5
Dolly(max velocity 8 km/h (5 mph))	I	±1.0	±0.75	+2.0/-0.0
Forklifting	S	±1.0	±0.75	+2.0/-0.0
Hoisting	I	1.5 in direction of travel		

Notes:
S - Loads occur simultaneously in the thee directions.
I – Loads occur independently in the thee directions except for gravity.
Above load factors act at the center of gravity of the cargo.
Cargo weighing <136 kgs. Subject to additional loads cause by vibroacoustics for applicable transportation modes.
For ground transportation, the structure/carrier vehicle should be designed for the occurrence of a 15.4 m/s wind in combination with the load factors.
Cargo support structure will be designed, or carrier operation constrained, or both to insure that cargo loads will not exceed the design load.
Limit load factors listed in this table may be superseded by limit load factors derived for specific transportation mode/vehicle, transportation handling fixtures and handling equipment.
Vertical g's are positive in the direction of gravity (downward).

3.2.7.1 CIR launch and return.

The CIR in its launch configuration and stowed CIR hardware shall be designed to withstand a minimum of two shuttle launches and landings in the MPLM.

3.3 Design and construction.

3.3.1 Materials, processes, and parts.

3.3.1.1 CIR specific material requirements.

3.3.1.1.1 Materials – general.

Materials used in the CIR shall meet the requirements as specified in paragraphs 208.3 and 209 of NSTS 1700.7, NSTS 1700.7 ISS Addendum, and FCF-PLN-0036.

3.3.1.1.2 Internal Thermal Control System (ITCS) Fluids.

a. The CIR shall use ITCS fluids that meet the requirements specified in SSP 30573.
b. The CIR shall meet the fluid system cleanliness levels specified in SSP 30573.
c. The CIR shall use internal materials that are compatible according to MSFC-SPEC-250, Table III or that will not create a potential greater than 0.25 V with the ISS system internal materials due to a dissimilar metal couple.

3.3.1.1.3 Connectors.

Connectors used in the CIR, external to the assembly level, shall consist of MIL-C-38999, MIL-C-5015, MIL-C-81569, MIL-C-83733, or SSQ 21635 as specified in SSP 30423, Figure 4.1-8.

3.3.1.1.4 External cleanliness.

a. The CIR external surfaces, with applicable PI hardware, shall conform prior to launch to Visibly Clean - Sensitive (VC - S) cleanliness requirements, as specified in SN-C-0005.
b. The CIR external surfaces, with applicable PI hardware, shall meet the minimum acceptable cleanliness environment as measured by the US Lab.

3.3.1.2 Toxic products and formulations.

The CIR shall meet the toxic product and formulation requirements as specified in FCF-PLN-0036.

3.3.1.3 Volatile organic compounds.

The CIR shall meet the volatile organic compound requirements as specified in FCF-PLN-0036.

3.3.1.4 Hazardous materials.

The CIR shall meet the hazardous material requirements as specified in FCF-PLN-0036.

3.3.1.5 Protective coatings.

The CIR shall meet the protective coating requirements as specified in FCF-PLN-0036.

3.3.2 Electromagnetic radiation.

3.3.2.1 Ionizing radiation.

Not applicable.

3.3.2.2 Nonionizing radiation.

Not applicable.

3.3.2.3 Operating environment.

Not applicable.

3.3.2.4 Generated environment.

Not applicable.

3.3.3 Nameplates and product marking.

3.3.3.1 Nameplates.

3.3.3.2 CIR identification and marking.

The CIR, all sub-rack elements (installed in the rack or separately), loose equipment, stowage trays, consumables, assemblies, crew accessible connectors and cables, switches, indicators, and controls shall be labeled as specified in SSP 57000 Appendix C.

3.3.3.2.1 CIR component identification and marking.

All CIR parts shall be legibly and permanently marked with a Part Identification Number (PIN) with the following exceptions:

a. Commercial-Off-the-Shelf (COTS) items marked with visible, permanent, and commercial identification.
b. Parts within a COTS assembly that are not subject to removal, replacement, or repair.
c. Parts within an assembly that are permanently installed and are not subject to removal, replacement, or repair.
d. Parts that cannot be physically marked or tagged due to lack of space or when marking would have a deleterious effect shall be temporarily tagged or packaged until the part is installed on the next higher assembly.

3.3.3.2.2 CIR lighting design.

a. CIR work surface specularity shall not exceed 20%. Paints listed in Table XV meet this requirement.
b. Lighting levels for tasks to be performed at CIR work sites shall be provided, as defined in Table XVI.
c. Medium CIR operational tasks shall utilize the ISS Portable Utility Light (PUL) specified in JSC 27199.
d. All text on surfaces intended to be read by the on orbit crew shall be black lusterless, 37038 as specified in FED-STD-595, on off-white, semi-gloss, 27722 background as specified in FED-STD-595.
e. All aluminum surfaces susceptible to wear shall be clear or black hard coat anodized or equivalent.
f. CIR components shall be exempt from the lighting design requirement if the surfaces are color coded to meet other requirements as specified herein, such as interior component surfaces, COTS components, fluid system tubing, and surfaces required by science or safety to exhibit specific characteristics.

3.3.3.2.3 Touch temperature warning labels.

Warning labels shall be provided at the surface site of any CIR component that exceeds a temperature of 49°C (120°F), including surfaces not normally exposed to the cabin, in accordance with the NASA IVA Touch Temperature Safety interpretation letter JSC, MA2-95-048.

3.3.3.2.4 Connector coding and labeling.

a. Both halves of CIR mating connectors shall display a code or identifier which is unique to that connection.
b. The labels or codes on CIR connectors shall be located so they are visible when connected or disconnected.
c. Each CIR electrical connector pin shall be uniquely identifiable in each electrical plug and each electrical receptacle. At least every 10^{th} pin must be labeled.

3.3.3.3 Portable fire extinguisher (PFE) and fire detection indicator labeling.

a. The CIR shall label the Portable Fire Extinguisher (PFE) access port with a SDD32100397-002 “Fire Hole Decal” specified in JSC 27260.
b. The CIR shall label the Fire Detection Indicator Light Emitting Diode (LED) “SMOKE INDICATION” as specified in MSFC-STD-275, using 3.96 mm (0.156 in.) letters, style Futura Demibold, and color 37038 (Lusterless Black) per FED-STD-595.

Table XV. Surface interior colors and paints

HARDWARE DESCRIPTION	COLOR	FINISH	PAINT SPECIFICATION PER FED–STD–595
Equipment Rack Utility Panel Recess	White	Semigloss	27925
Equipment Rack Utility Panel Text Characters	Black	Lusterless	37038
International Std. Payload Rack Primary Structure	Off-White	Semigloss	27722
ISPR Utility Panel Recess	White	Semigloss	27925
ISPR Utility Panel Recess Text Characters	Black	Lusterless	37038
Functional Unit Rack (Primary Structure)	Off-White	Semigloss	27722
Functional Unit Utility Panel Recess (as applicable)	White	Semigloss	27925
Functional Unit Utility Panel Recess Text Characters	Black	Lusterless	37038
Rack Front Aisle Extensions	Off-White	Semigloss	27722
Ceiling Rack Face Plates	Off-White	Semigloss	27722
Port Rack Face Plates	Off-White	Semigloss	27722
Starboard Rack Face Plates	Off-White	Semigloss	27722
Floor Rack Face Plates	Off-White	Semigloss	27722
Ceiling Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Port Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Starboard Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Floor Rack Utility Panel Closeouts	Off-White	Semigloss	27722
Stowage Trays	Off-White	Semigloss	27722
Stowage Tray Handle Straps (any location)	Blue material	Semigloss	25102 or equiv.
Common Seat Track Interface	Clear (Anodized)	Semigloss	none
Glovebox (Aluminum or Plastic)	Medium Gray	Gloss	16329 or 16373
Glovebox (Aluminum)	White	Gloss	17925
Glovebox (Aluminum or Plastic)	Off-White	Gloss	17722
Glovebox (Aluminum)	Tan	Gloss	10475
EXPRESS Program Rack Utility Panels	Off–White	Gloss	17875

Table XVI. CIR required illumination levels

Type of Task	Required Lux (Foot-Candles)*
Medium payload operations (not performed in the aisle) (e.g., payload change-out and maintenance)	325 (30)
Fine payload operations (e.g., instrument repair)	1075 (100)
Medium glovebox operations (e.g., general operations, experiment set-up)	975 (90)
Fine glovebox operations (e.g., detailed operations, protein crystal growth, surgery/dissection, spot illumination)	1450 (135)

* As measured at the task site

3.3.3.4 Electrostatic discharge sensitive (ESD) parts labeling.

Labeling of EPCE susceptible to ESD up to 15,000 V shall be in accordance with MIL-STD-1686. These voltages are the result of charges that may be accumulated and discharged from ground personnel or crew members during equipment installation or removal.

3.3.4 Workmanship.

The CIR, with applicable PI hardware, shall conform to the workmanship standards in accordance with NHB 5300.4(1B).

3.3.5 Interchangeability.

All ORU’s that have the same part number shall be functionally and dimensionally interchangeable.

3.3.5.1 On orbit interchangeability.

The following assemblies and components shall be interchangeable on orbit:

a. IPP
b. IOP
c. EPCU
d. GC Assembly
e. GC Outlet Valve Assembly
f. FCU
g. IOP Disk Drives
h. Exhaust Pump Assembly
i. Exhaust Vent Manifold Assembly
j. Vent Manifold Assembly
k. Exhaust Manifold Assembly
l. MV4 Manifold Assembly
m. Fuel Manifold Assembly
n. Diluent/Pre-Mix Manifold Assembly
o. Static Mixer Assembly
p. High Pressure Oxygen Manifold Assembly
q. Nitrogen/High Pressure Manifold Assembly
r. All Temperature Sensors
s. All Pressure Sensors
t. All Solenoid Valve Coils
u. Bottle Assemblies
v. All Adsorber Cartridge Assemblies
w. All Diagnostic Modules/Packages
x. ATCS Air Filters

3.3.6 Safety.

The CIR, with applicable hardware and software, shall meet all applicable requirements of NSTS 1700.7 ISS Addendum.

3.3.6.1 Fire Prevention.

The CIR shall meet the fire prevention requirements specified in NSTS 1700.7 ISS Addendum, paragraph 220.10 a.

3.3.6.1.1 Smoke detector.

a. The CIR, which contains potential fire sources and has forced air circulation, shall use a smoke detector that meets the requirements specified in D683-10007 and SSP 30262:013.
b. The CIR shall provide a smoke detector interface at the J43 connection with interface characteristics meeting the requirements specified in paragraph 3.3.6.1.1.1.

3.3.6.1.1.1 Maintenance switch, smoke detector, smoke indicator, and CIR fan interfaces.

a. The CIR power off command interface characteristics shall be in accordance with Table XVII.
b. The CIR power cut-off shall be implemented with a manually operated two-position lever lock switch.

3.3.6.1.1.2 Smoke detector analog interface characteristics.

The electrical characteristics (signal source) of the active driver interface shall be in accordance with Table XVIII.

Table XVII. Bi-level data characteristics (switch contact)

PARAMETER	ENG. UNIT	ISPR
Type Transfer		Floating (Isolation resistance >1MΩ) dc coupled
I/F Resistance (closed)	Ω	< 20
I/F Resistance (open)	MΩ	> 1
Open Circuit Leakage Current	μA	0 to 100
Operating Current (closed)	mA	0.2 to 30
Minimum Open Circuit Voltage	V	20

Table XVIII. Electrical characteristics envelope of analog signals

PARAMETER	ENG. UNIT	ANALOG SIGNALS
TYPE	N/A	Balanced
TRANSFER	N/A	DC Coupled
ANALOG VOLTAGE (line to line)	V	–5 to +5
RIPPLE AND NOISE	mV Peak (1)	±20
CAPACITY (Maximum)	nF	N/A
IMPEDANCE	Ohm	≤1K
OVERVOLTAGE PROTECTION (Min)	V	±15
FAULT VOLTAGE EMISSION (Max)	V	±15
FAULT CURRENT LIMIT. (Maximum)	mA	±10 (2)

Notes: (1) Measurement Bandwidth ≥ 50 MHz
(2) ISPR AAA= 30mA max

3.3.6.1.1.3 Discrete command built-in-test interface characteristics.

The discrete command built-in-test (BIT) interface characteristics (signal source) shall be in accordance with Table XIX.

Table XIX. Electrical characteristics of bit interface

PARAMETER	ENG. UNIT	SMOKE SENSOR
TYPE	N/A	Single-Ended
TRANSFER	N/A	DC Coupled
I/F VOLTAGE (TRUE) (line to line)	V	<1.5
OPERATING CURRENT ON (TRUE) (Max)	mA	2
RIPPLE AND NOISE	mV Peak (1)	±100
FAULT VOLTAGE EMISSION (Max)	V	±5
FAULT CURRENT EMISSION (Max)	mA	5

Notes: (1) Measurement Bandwidth ≥ 50 MHz
(2) If interface is active (on or true)

3.3.6.1.1.4 Smoke indicator electrical interfaces.

The smoke indicator electrical interface characteristics shall be in accordance with Table XX.

Table XX. Smoke indicator interface characteristics

PARAMETER	ENG. UNIT	SMOKE INDICATOR
TYPE	N/A	Floating
TRANSFER	N/A	DC Coupled
LOAD CURRENT (max)	mA	10
OVERVOLTAGE PROTECTION RANGE	V	±20
FAULT CURRENT EMISSION (max)	mA	24
IMPEDANCE (DC)	Ohm	>650

Note: At zero current rating (infinite load impedance)

3.3.6.1.1.5 Fan ventilation status electrical interfaces.

The CIR fan ventilation status electrical interface characteristics shall be in accordance with paragraph 3.3.6.1.1.2. The air is circulated though the smoke sensor in the CIR by a fan controlled and powered by the CIR.

3.3.6.1.1.6 Rack maintenance switch(rack power switch)/fire detection support interface connector.

a. CIR connector P43 mating requirements to the UIP Connector J43 shall be as specified in paragraph 3.1.5.1.
b. The CIR Maintenance Switch/FDS P43 Connector shall meet the pinout interfaces of the UIP J43 Connector as specified in SSP 57001, paragraph 3.3.6.
c. CIR Maintenance Switch/FDS P43 Connector shall meet the requirements of SSQ 21635 or equivalent.

3.3.6.1.2 Fire detection indicator.

a. The CIR shall provide a red Fire Detection Indicator LED in an easily visible location on the front of the rack that is powered by the ISS when the smoke detector senses smoke.
b. The CIR shall provide a fire detection indicator interface at the J43 connection with interface characteristics meeting the requirements specified in paragraph 3.3.6.1.1.1.

3.3.6.1.3 Forced air circulation indication.

The CIR shall provide a signal and data indicating whether or not the air flow specified in SSP 30262:013, paragraph 3.6.6 is being provided to the smoke detector when the smoke detector is in use.

3.3.6.1.4 Fire parameter monitoring in the CIR.

a. The CIR shall provide manual and automatic capabilities to terminate forced air circulation (if present) and power to the CIR.

Note: Use of the Rack Maintenance Switch meets the manual requirement. For the CIR where the P/L Multiplexer-Demultiplexer (MDM) provides the monitoring function, the P/L MDM is capable of sending a command to the module Remote Power Controller (RPC) that will power off the CIR to meet the automatic requirement.

b. The CIR shall respond to an “out of bounds” condition by sending data to indicate the location and cause of the “out of bounds” condition to the payload MDM in the format specified in paragraph 3.4.1.1.5.4.

3.3.6.1.5 Fire suppression access port accessibility.

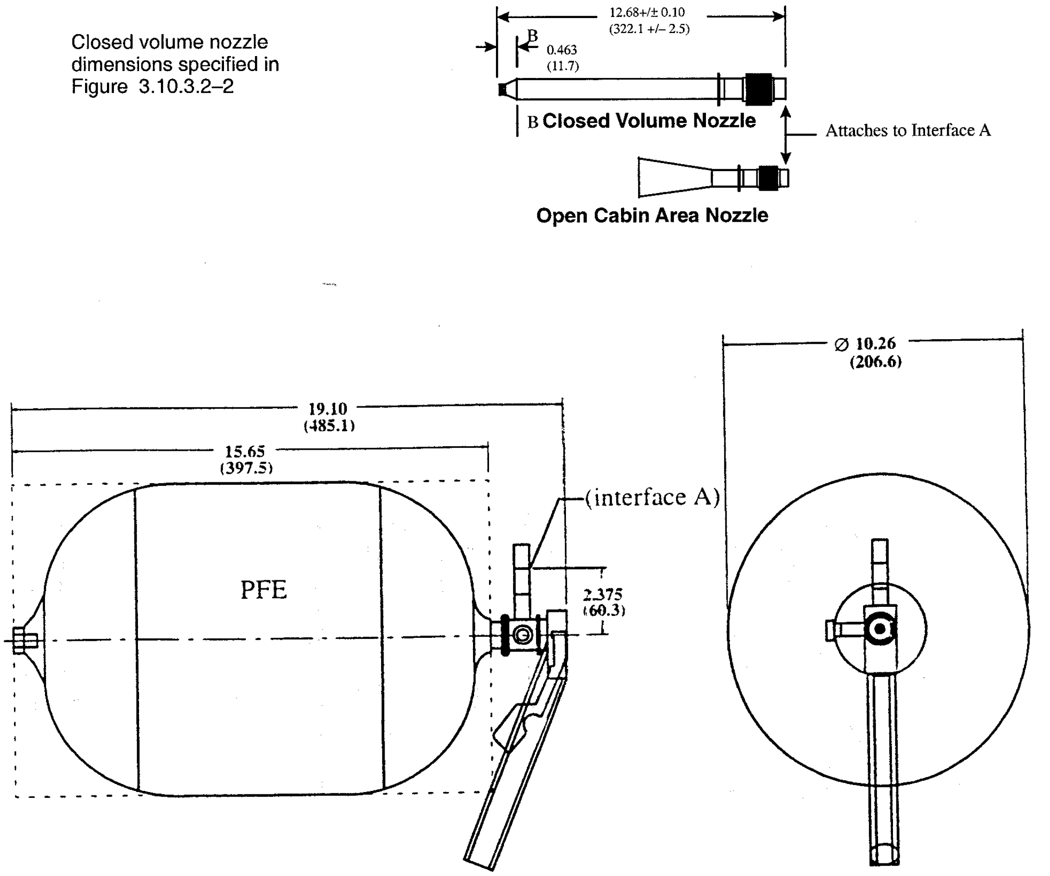
The CIR shall have a front face designed to accommodate the PFE nozzle and bottle specified in Figure 29 and Figure 30 so the PFE nozzle can interface to the PFE port.

3.3.6.1.6 Fire suppressant distribution.

The internal layout of the CIR shall allow ISS PFE fire suppressant to be distributed to the entire volume that PFE access port serves, lowering the oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute.

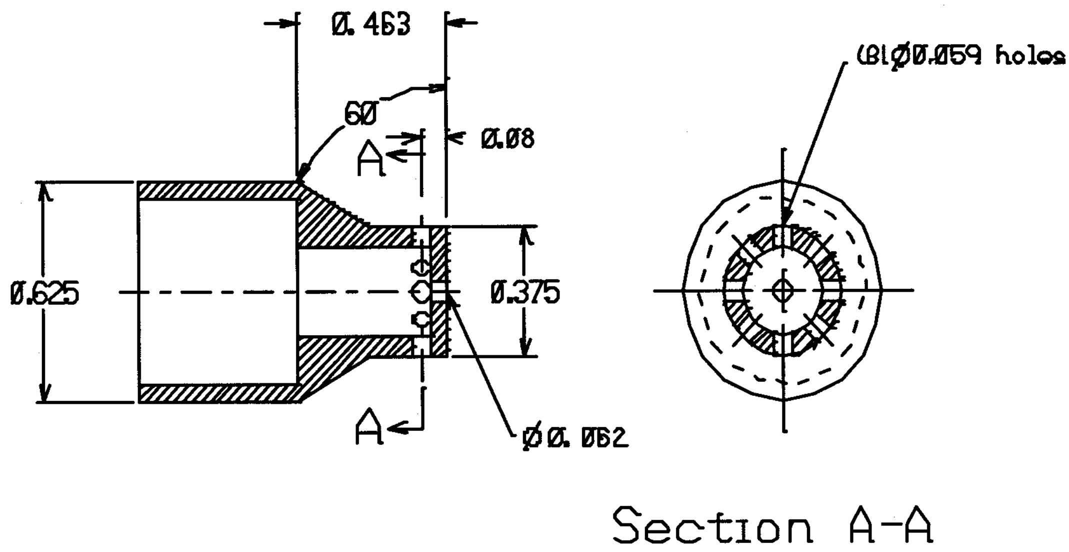
3.3.6.2 CIR front surface temperature.

The CIR shall be designed such that the average front surface temperature is less than 37°C (98.6°F) and partial limit not to exceed 49° C (120°F).



Note: Measurements from PFE centerline to point B with the closed cabin Nozzle attached is approximately 14.59 inches (370.6 mm)

Figure 29. Manual fire suppression hardware envelope



Note: Linear dimensions are in inches, angular dimensions are in degrees.

Figure 30. Closed volume PFE nozzle

3.3.6.3 Electrical hazards.

CIR electrical equipment shall incorporate the following controls as specified below:

a. If the exposure condition is below the threshold for shock (i.e., below maximum leakage current and voltage requirements as defined within this section), no controls are required. Non-patient equipment with internal voltages not exceeding 30 Vrms or dc nominal (32 Vrms or dc maximum) will contain potentials below the threshold for electrical shock.
b. If the exposure condition exceeds the threshold for shock, but is below the threshold of the let-go current profile (critical hazard) as defined in Table XXI, two independent controls (e.g., a safety (green) wire, bonding, insulation, leakage current levels below maximum requirements) shall be provided such that no single failure, event, or environment can eliminate more than one control.
c. If the exposure condition exceeds both the threshold for shock and the threshold of the let-go current profile (catastrophic hazardous events) as defined in Table XXI, thee independent controls shall be provided such that no combination of two failures, events, or environments can eliminate more than two controls.
d. If two dependent controls are provided, the physiological effect that a crew member experiences as a result of the combinations of the highest internal voltage applied to or generated within the equipment and the frequency and wave form associated with a worst case credible failure shall be below the threshold of the let-go current profile as defined in Table XXI.

e. If it cannot be demonstrated that the hazard meets the conditions of paragraph a, b, or c above, thee independent hazard controls shall be provided such that no combination of two failures, events, or environments can eliminate more than two controls.

Table XXI. Let-go current profile theshold versus frequency

Frequency (Hertz)	Maximum Total Peak Current (AC + DC components combined) (milliamperes)
DC	40
15	8.5
2000	8.5
3000	13.5
4000	15.0
5000	16.5
6000	17.9
7000	19.4
8000	20.9
9000	22.5
10000	24.3
50000	24.3

(Based on 99.5 Percentile Rank of Adults)

3.3.6.4 Connector mating.

a. The design of electrical connectors shall make it impossible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can be created.
b. CIR and on orbit support equipment, wire harnesses, and connectors shall be designed such that no blind connections or disconnections must be made during CIR installation, operation, removal, or maintenance on orbit unless the design includes scoop proof connectors or other protective features (NSTS 1700.7 ISS Addendum, paragraph 221).
c. CIR equipment, for which mismating or cross-connection may damage ISS-provided equipment, plugs, and receptacles (connectors), shall be selected and applied such that it cannot be mismatched or cross-connected in the intended system as well as adjacent systems. Although identification markings or labels are required, the use of identification alone is not sufficient to preclude mismating.
d. For all other CIR connections, combinations of identification, keying and clocking, and equipment test, and checkout procedures shall be employed at the payload’s discretion to minimize equipment risk while maximizing on orbit operability.

3.3.6.5 Mating/demating of powered connectors.

The CIR EPCE shall meet the electrical safety requirements as defined in NSTS 1700.7 ISS Addendum. Payloads shall comply with the requirements for mating/demating of powered connectors specified in NSTS 18798, MA2-97-093.

Note: The module can provide one verifiable upstream inhibit which removes voltage from the UIP and UOP connectors. The module design will provide the verification of the inhibit status at the time the inhibit is inserted.

3.3.6.6 Safety-critical circuit redundancy.

The CIR EPCE shall meet the electrical safety requirements as defined in NSTS 1700.7 ISS Addendum. The CIR EPCE connected to Interface B shall meet the safety-critical circuits redundancy requirements defined in NSTS 18798.

3.3.6.7 Rack maintenance switch (rack power switch).

The CIR shall provide a guarded, two-position, manually operated switch installed in a visible and accessible location on the front of the CIR that removes all power to the CIR.

3.3.6.8 Power switches/controls.

The following power switches/controls requirements apply to power to power interfaces with open circuit voltage exceeding 30 Vrms or dc nominal (32 Vrms or dc maximum).

a. Switches/controls performing on/off power functions for all power interfaces shall open (dead-face) all supply circuit conductors except the power return and the equipment grounding conductor while in the power-off position.
b. Power-off markings and/or indications shall be used only if all parts, with the exception of overcurrent devices and associated EMI filters, are disconnected from the supply circuit.
c. Standby, charging, or other descriptive nomenclature shall be used to indicate that the supply circuit is not completely disconnected for this power condition.

3.3.6.9 Ground fault circuit interrupters (GFCI)/portable equipment dc sourcing voltage.

a. A non-portable utility outlet with output voltages exceeding 30 Vrms or dc nominal (32 Vrms or dc maximum) intended to supply power to portable equipment shall include a GFCI, as an electrical hazard control, in the power path to the portable equipment.
b. GFCI trip current dc detection shall be independent of the portable equipment’s safety (green) wire.
c. GFCI trip current ac detection shall be dependent on the portable equipment’s safety (green) wire when the safety (green) wire is present.
d. Portable equipment that has internal voltages greater than 30 Vrms or dc nominal (32 Vrms or dc maximum) and has a credible fault path or return path to a crew member shall include GFCI protection for that credible path with trip point characteristics such that tripping will not exceed the currents specified in the profile shown in Table XXI.
e. GFCI will be designed to trip below the threshold of let-go based upon the 99.5 percentile rank of adults. Non-portable utility outlets supplying power to portable equipment shall include a GFCI with trip point characteristics such that tripping will not exceed the currents specified in the profile shown in Table XXI.

f. GFCI's shall remove power within 25 ms upon encountering the fault current.
g. GFCI shall provide an on orbit method for testing trip current detection threshold at dc and at a frequency within the maximum human sensitivity range of 15 to 70 Hz.

3.3.6.10 Portable equipment/power cords.

a. Non-battery powered portable equipment shall incorporate a thee-wire power cord.
b. Fault currents resulting from a single failure within a non-battery powered portable equipment that has internal voltage above 30 Vrms or dc nominal (32 Vrms or dc maximum) and has a credible fault path or return path to the crew member shall not exceed the total peak currents specified in Table XXI for fault current frequencies of 15 Hz and above.

3.3.6.11 Overload protection.

3.3.6.11.1 Device accessibility.

An overload protective device shall not be accessible without opening a door or cover, except that an operating handle or operating button of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts may project outside the enclosure.

3.3.6.11.2 Extractor-type fuse holder.

The design of the extractor-type fuse holder shall be such that the fuse is extracted when the cap is removed.

3.3.6.11.3 Overload protection location.

Overload protection (fuses and circuit breakers) intended to be manually replaced or physically reset on orbit shall be located where they can be seen and replaced or reset without removing other components.

3.3.6.11.4 Overload protection identification.

Each overload protector (fuse or circuit breaker) intended to be manually replaced or physically reset on orbit shall be readily identified or keyed for its proper value.

3.3.6.11.5 Automatic restart protection.

Controls shall be employed that prevent automatic restarting after an overload-initiated shutdown.

3.3.6.12 Sharp edges and corners protection.

The CIR design shall protect crew members from sharp edges and corners during all crew operations in accordance with NSTS 1700.7 ISS Addendum, paragraph 222.1.

3.3.6.13 Holes.

Holes that are round or slotted in the range of 10.0 to 25.0 mm (0.4 to 1.0 in.) shall be covered.

3.3.6.14 Latches.

Latches that pivot, retract, or flex so that a gap of less than 35 mm (1.4 in.) exists shall be designed to prevent entrapment of a crew member's appendage.

3.3.6.15 Screw and bolts.

Threaded ends of screws and bolts accessible by the crew and extending more than 3.0 mm (0.12 in.) shall be capped to protect against sharp threads.

3.3.6.16 Securing pins.

Securing pins shall be designed to prevent their inadvertently backing out above the handhold surface.

3.3.6.17 Levers, cranks, hooks, and controls.

Levers, cranks, hooks, and controls shall not be located where they can pinch, snag, or cut the crewmembers or their clothing.

3.3.6.18 Burrs.

Exposed surfaces shall be free of burrs.

3.3.6.19 Locking wires.

a. Safety wires shall not be used on fasteners which must be unfastened for on orbit removal or replacement.
b. All fracture-critical fasteners as defined in SSP 52005 (paragraph 5.6, Fastener Requirements, and Appendix B, Glossary of Terms), which must be unfastened for on orbit removal or replacement shall be safety cabled or cotter pinned.

3.3.6.20 Audio devices (displays).

a. The design of audio devices (displays) and circuits shall protect against false alarms.
b. All audio device (displays) shall be equipped with circuit test devices or other means of operability testing.
c. An interlocked, manual disable shall be provided if there is any failure mode which can result in a sustained activation of an audio device (display).

3.3.6.21 Egress.

All CIR egress requirements shall be in accordance with 1700.7 ISS Addendum, paragraph 205.

3.3.6.22 Failure tolerance.

The CIR shall be single fault tolerant for the operation of a computer to identify failures to allow for active troubleshooting.

3.3.6.23 Failure propagation.

a. The CIR shall be designed such that a failure within an assembly will not induce any failure external to the failed assembly.
b. The CIR shall be designed such that a failure within the CIR will not induce a failure to any system or component external to the CIR.

3.3.6.24 Separation of redundant paths.

Alternate or redundant electrical functional paths shall be provided for all paths where electrical or electronic harnesses cannot be replaced on orbit.

3.3.6.25 Incorrect equipment installation.

The CIR assemblies and components that are replaceable on orbit shall contain physical provisions to preclude incorrect installation which may result in damage to equipment or hazardous conditions.

3.3.6.26 Chemical releases.

Chemical releases to the cabin air shall be in accordance with paragraphs 209.1 a. and 209.1 b. in NSTS 1700.7 ISS Addendum.

3.3.6.27 Single event effect (SEE) ionizing radiation.

The CIR, with applicable PI hardware, shall be designed not to produce an unsafe condition or one that could cause damage to equipment external to the CIR as a result of exposure to SEE ionizing radiation assuming exposure levels specified in SSP 30512, paragraph 3.2.1, with a shielding thickness of 25.4 mm (1000 mils).

3.3.6.28 Potential hazardous conditions.

a. The CIR shall determine if any out-of-tolerance conditions will lead to a hazardous condition and take steps necessary to prevent the hazardous condition.
b. Any autonomous reconfigurations performed to prevent a hazardous condition from occurring shall be capable of being overridden.

3.3.6.29 Withstand external environment.

The CIR shall be designed to withstand changes in its external environment when powered, where if hazardous conditions are created, the hazardous conditions will not propagate to systems internal or external to the FCF. Unpowered hazardous conditions created by external changes are covered in paragraph 3.3.6.

3.3.6.30 CIR hazard report requirements.

The following are the specific safety requirements generated from the PSRP CIR Safety Review.

3.3.6.30.1 EMI hazards.

These hazards are covered in paragraph 3.2.6.4.3.18.

3.3.6.30.2 Bottle hazards.

a. Bottle valves shall contain a round handle, which minimizes the possibility of inadvertent opening.
b. Bottle valves shall be slow opening, with a minimum of 8 turns to full open.
c. Bottles shall have a self-sealing QD, which will prevent flow if the valve is open for any reason.
d. Bottle dust caps on QD shall have six equally spaced radial vent holes to prevent propulsive force.
e. Manual valve shall prevent fluid flow in the event QD fails and/or non-propulsive cap fails.
f. Flight operations shall be conducted in accordance with approved procedures for:
    1. Handling of bottle and valve.
    f. Removal of QD cover.
    g. Attachment into bottle holder, which restrains bottle before opening manual valve.
g. All bottle QD's shall be designed to hold bottle in place.
h. All bottle holder/restraint shall be designed to hold bottle in place in event of QD failure.

3.3.6.30.3 High oxygen/high pressure hazards.

a. Materials in high oxygen/ high pressure (13790 kPa (2000 psi) portion and materials in low pressure portion (<931 kPa (135 psi)) of fluid system shall be in accordance with MSFC-HDBK-527/JSC 090604/MAPTIS Data base for 85 % oxygen environment.
b. Supply bottles shall be limited to (13790 kPa (2000 psi) 85% oxygen.
c. Gas velocities shall be controlled by designing flow paths without convergence.
d. Pressure spikes shall be controlled by use of slow opening valves and avoidance of dead ends.
e. System shall be designed to limit effect of materials.
f. High pressure oxygen area shall be cleaned to pure oxygen levels prior to launch.
g. Low pressure oxygen areas shall be designed to be cleaned and maintained on orbit to standard fluids cleaning levels.
h. Gas velocities and impingement points that are exposed to oxygen shall be limited.

i. The bottle contents, pressure and size limit pressure of O2 rich gas in the chamber to less than half the flammability threshold (for all CIR chamber materials) for specific diluent for O2 percentage shall be controlled to prevent fires.
j. Oxygen bottle supply ports shall be keyed to allow only O2 bottles to fit only in O2 ports.
k. All bottles/manifold shall be color-coded based on content for crew to have a visual indication of bottle status.
l. All bottles/manifold shall be alpha numerically labeled.
m. An Oxygen compatible (materials and cleanliness) check valve shall be in the N2 and diluent supply lines immediately up stream of the O2 junction.
n. An Oxygen compatible (materials and cleanliness) solenoid valve will be in the N2 and Diluent supply lines immediately up stream of the O2 junction.

3.3.6.30.4 Leakage hazard.

a. For permanent joints welds shall used to the maximum extent possible.
b. For areas where dissimilar metals require joining or maintainability (low number of cycle times) preclude welding non-welded joints shall be used.
c. For high cycle make/break seals dual seals shall be used.
d. An on orbit leak integrity check shall be performed.
e. All items that might be exposed to toxic fluids shall be categorized as fracture critical and meet the fracture control requirements of NASA STD 5003 and SSP 52005.
f. A separate hazard report shall be generated by each experiment which has the potential to use or produce toxic fluids to evaluate the CIR system in conjunction with the payload for controlling the specific toxic fluids at the levels which will be present.
g. Toxic by-product containing test points shall be cleaned up by circulating through an adsorber cartridge.
h. Toxic by-product containing test points shall be vented and back filled with air/nitrogen before crew access to the CIR.
i. All crew operations which address crew access to the Combustion Chamber shall be performed using approved procedures, including verifying that the clean up and evacuation have been performed.
j. Placards on front of the CIR shall alert crew when potentially toxic test points are run.
k. Opening of chamber lid by the crew to lifting a locking pin shall be incorporated into the CIR design.
l. Crew procedures for maintenance of fluid system hardware shall be performed using approved procedures.
m. On orbit leak integrity checks shall be performed before toxic test points to insure leak integrity of system after maintenance.

3.3.6.30.5 Chamber door hazards.

a. Chamber door shall be designed such that it can only be closed in one way.
b. Chamber door mechanism shall provide a lock which can only be engaged when door is properly closed.
c. All flight crew operations including closure and opening of the Chamber door shall be performed using approved procedures.

d. Chamber door shall be designed to be self relieving.
e. Chamber door shall be designed with required factors of safety for its maximum design pressure (MDP).

3.3.6.30.6 Gas flow hazards.

a. A computer processor and mass flow controller combination shall control amounts of oxygen, fuel and diluent in the chamber.
b. Two independent sets of timers with solenoids/flow restrictors shall limit fuel flow into chamber.

3.3.6.30.7 Oxygen concentration hazards.

High oxygen concentration and fuel bottle sizes, pressures and concentrations shall be controlled for free volume of rack.

3.3.6.30.8 Diluent gas bottle hazards.

The bottle size for diluent shall be sized such that if entire bottle contents were leaked into cabin the O2 of the cabin would not be below 19%.

3.3.6.30.9 Pressure control hazards.

a. The CIR shall be designed to incorporate a regulator down stream of each gas source used within the chamber controls pressure to less than 827 kPa(120 psi).
b. The CIR shall be designed such that pressure switches downstream of the regulators which shut off source solenoids if pressure is above 896 kPa (130 psi) for gases used in the chamber.
c. The CIR shall be designed such that transducers in low pressure section of pressurized subsystem monitored by a controller and all solenoids close if 861 kPa(125 psi) is exceeded for gases used in the chamber.
d. The CIR shall be designed such that the chamber pressure is monitored by the controller, so that any pressure over specified (experiment dependent but less than 896 kPa (130 psi)) amount and all solenoids shut.
e. The CIR shall be designed to incorporate a pressure switch in chamber that shuts all supply solenoids if Chamber pressure of 931 kPa (135 psia) is reached.
f. The CIR shall be designed such that regulators down stream of the GC carrier gas sources controls pressure to less than 654 kPa (95 psi).
g. The CIR shall be designed such that redundant relief valves set at 724 and 734 kPa (105 and 107 psi) relieve in the event of a regulator failure, so that the worst case flow will not exceed individual relief valve maximum flow capability.
h. The CIR shall be designed such that regulators down stream of calibration gas and chamber sample line controls pressure to less than 119kPa (17.2 psi).
i. The CIR shall be designed such that pressure transducers monitor the calibration gas line and chamber sample line respectively, so the computer will shut solenoid valves if pressure is above acceptable value 170 kPa (25 psi) and will open solenoids to vent gas to ISS vent.

j. The CIR shall be designed such that pressure switches downstream of calibration gas and chamber sample line controls pressure to less than 160 kPa (23 psi) by closing solenoid valves.
k. All CIR carrier gas bottle pressures shall be kept below the 2000 psia MDP of carrier gas system.
l. The CIR shall be designed such that two manual valves must be opened to allow chamber to be vented.
m. The manual vent system shall contain an orifice to control worst case flow from chamber at its MDP to prevent over 40 psi at ISS vent.
n. The CIR shall be designed such that a regulator at exit of CIR vent system set at below 40 psia regulates downstream pressure.
o. The CIR shall be designed such that a mass flow controller commanded by a computer controls flow based on pressure transducer to ensure down stream pressure below 40 psia.
p. The CIR shall be designed such that a pressure switch shuts solenoid valve if 40 psia is reached at vent.

3.3.6.30.10 Pressurization hazards.

a. CIR pressurized subsystem hardware shall be designed to the following factors of safety (FS): Combustion Chamber FS = 1.5 X MDP (based on yield) and 2.0 MDP based on ultimate; Gas Bottles FS = 2.0 bottle MDP (based on yield) and 2.5 X MDP (based on ultimate); lines/fittings (<1.5 in.) FS = 4.0 X respective line MDP; other system components FS= 2.5 X respective MDP and all lines, fittings, components are be proof pressure tested to 1.5 X MDP.
b. Gas bottles shall be designed as leak-before-burst pressure vessels and tested in accordance with MIL-STD 1522A as modified by NSTS 1700.7B, paragraph 208.4.
c. The combustion chamber shall be designed as a pressure vessel containing hazardous fluids to comply with the intent of MIL-STD 1522A (Approach A), as modified by NSTS 1700.7B, paragraph 208.4a.
d. Procedures shall be developed to ensure flight bottles are not overfilled during ground operations.
e. Portions of the CIR which will be exposed to vacuum on orbit shall be designed to withstand an internal vacuum.
f. Metallic materials shall be selected in accordance with FCF-PLN-0036.
g. Ground handling procedures shall be developed to preclude damage to flight bottles storage, launch and insertion.
h. Crew procedures for proper handling of bottles on orbit shall be developed.

3.3.6.30.11 Brittle materials hazard.

a. Structural brittle structural materials exposed to pressure loads shall be designed to meet the fracture control requirements of NASA STD 5003 and SSP 52005 using a factor of safety of 3.0 (based on ultimate) times chamber MDP based on the minimum guaranteed tensile strength provided by the manufacture.
b. Chamber windows shall be designed to be recessed and covers installed over outside surface of windows to prevent scratching of window during ground handling.

c. Ground handling procedures shall be developed to preclude damage during buildup and test.
d. The chamber windows shall be designed to allow control of on orbit assembly by detailed installation procedures.
e. The design of window shall prevent metal to glass contact, no bonding of seal to glass and no contact of coating with seal.
f. The CIR shall develop on orbit procedures that will be in place to alert crew to possibility of damage to windows.
g. The chamber guide rail tolerances shall preclude PI hardware contact with inside surface of (recessed) windows during installation of PI hardware into chamber.

3.3.6.30.12 Particle hazards.

a. The CIR shall be designed such that a 40-micron sintered metal filters are located inside any adsorber cartridge at the inlet and the outlet.
b. The CIR shall be designed such that each end of each adsorber cartridge will have a self sealing quick disconnect and a manual valves which will seal off the canister upon removal.
c. The CIR shall design adsorber cartridges for minimal dusting.
d. Loading procedure for CIR adsorber cartridges to control particle size to greater than 40 microns shall be developed.

3.3.6.30.13 Incorrect bottle installation hazards.

This hazard is covered in paragraphs 3.3.3.2.4 and 3.3.6.25.

3.3.6.30.14 Battery hazards.

a. Any CIR assembly requiring a battery shall install a fuse the ground side of the battery which will be rated to blow below the current limit for the cell.
b. Any CIR assembly requiring a battery shall install a blocking diode will be in place upstream of the battery which will prevent charging.
c. Any CIR assembly requiring a battery shall change out battery before it drops below life margin.
d. Any CIR assembly requiring a battery shall design the battery case sealed corrosion resistant material.
e. Any CIR assembly requiring a battery shall design such that the maximum assembly temperature is below rated battery temperature.

3.3.6.30.15 Large moving masses hazard.

a. Any CIR assembly with the potential of large moving masses shall have motion dampers which will prevent momentum build up if the crewmember releases the mass.
b. Any CIR assembly with the potential of large moving masses shall have pinchpoints eliminated or covered.

3.3.6.30.16 Structural loads hazards.

This hazard is covered in paragraph 3.2.6.4.1 and FCF-PLN-0036.

3.3.6.30.17 Rack door hazards.

a. The CIR shall develop a configuration check sheet for door mechanism condition for use before launch.
b. The door latch mechanism shall be designed to show positive indicators on door mechanism to show status.

3.3.6.30.18 Fluid line and fittings hazards.

a. All CIR pressurized lines and fittings shall be designed with an ultimate safety factor greater than or equal to 4.0 X MDP and pressure components (valves and filters) have been designed with a factor of safety greater than or equal to 2.5 X MDP.
b. All materials used in fluid lines and fittings shall be selected in accordance with FCF-PLN-0036.
c. The fluid loop hardware shall be designed to be assembled per approved procedures.
d. All quick disconnects shall be designed to meet the leak rate requirements specified herein.

3.3.6.30.19 Thermal hazards.

a. All CIR electrical components shall be designed to have a lower temperature at steady state with no cooling than the flammability level of the materials that comprise the components.
b. The CIR shall be designed such that active thermal shutdown (monitor of component by IOP) or thermal fuses incorporated into the design to shut off the power in over temperature conditions for those components which have not been proven by analysis to be safe in a loss of cooling situation.

3.3.6.30.20 High temperature hazards.

a. The CIR ECS shall be designed to have a closed-loop thermal control system (incorporates automatic thermal switches to inhibit power to the heat generating component(s) and the system if the cooling loop fails).
b. The CIR ECS shall be designed to preclude crew contact with surfaces exceeding touch temperature limits (rack doors, proper insulation of components, guards, crew procedures).
c. The ECS shall be designed to control temperature at steady state on condition of component.
d. The ECS shall be designed for fail-safe thermal control and temperature monitoring (limit on temperature that component will increase or decrease to if failed on, thermal fuse, bi-metal switches).

3.3.6.30.21 Rotating equipment hazards.

a. CIR rotating equipment shall be analyzed for maximum worst case speed of item and for worst case maximum energy in accordance with SSP 52005.

b. CIR rotating equipment shall be contained in accordance with SSP 52005.

3.3.6.30.22 Electrical power hazards.

This hazard is covered in paragraph 3.3.6.3.

3.3.6.30.23 Shock hazards.

This hazard is covered in paragraph 3.3.6.3.

3.3.6.30.24 Laser containment hazard.

a. Laser diodes use design shall be such that no direct optical path to crew personnel exists during normal operations, i.e. optical path from laser diode to chamber during normal operations is contained within enclosures and all windows are covered by build-in light shields and rack door.
b. Laser diode use shall comply with ANSI Z 136.1.
c. Power shall be removed from laser diode prior to nominal chamber access or maintenance activities as follows:

Inhibit #1: The laser diode shall be commanded off by the crew using the laptop communicating with the CIR. The solid state control is normally off when not powered.

Inhibit #2: Each rack shall have an EPCE which controls all power into that Rack. The EPCE can be commanded or switched off. The on/off state of the EPCE is monitored via the status lamps on the front of the EPCE.

3.3.6.30.25 Inadvertent gas venting hazards.

a. A computer shall check that bleed path is shut before opening oxygen supply (or premix supply) or checks that oxygen supply (or fuel supply) is shut before bleeding down O2 manifold (or premix manifold).
b. The CIR shall design a hardware interlock between the oxygen and premix solenoid valves with a solenoid valve, so that one cannot be powered when the other is powered.
c. An additional computer other than the one listed in 3.3.6.30.25a shall act as a watch dog over the first computer operation by monitoring the oxygen and premix solenoid valves with a solenoid valve to be sure that the two valves are not open at the same time, so that if the valves are open at the same time the monitoring computer will tell the primary to shut the valves, and if that fails, the monitoring computer will command the EPCE to cut power to the supply for that portion of the CIR which will cause the normally closed solenoids to close.

3.3.7 Human performance/human engineering.

3.3.7.1 Strength requirements.

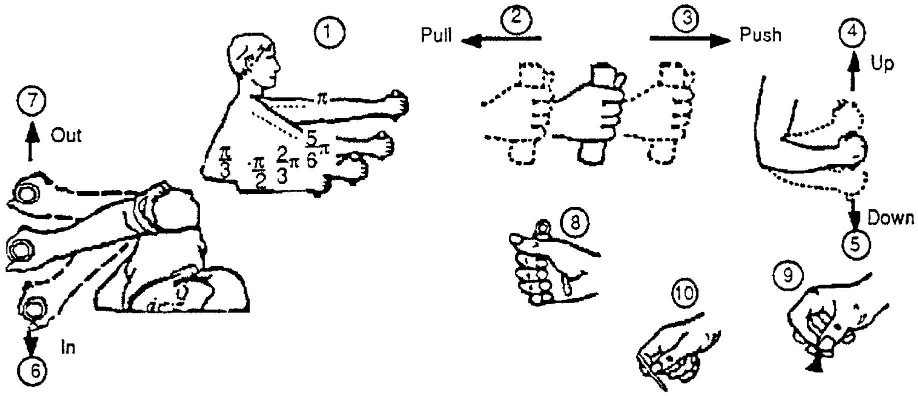
Forces and torques required to remove, replace, operate, control, and maintain CIR hardware and equipment on orbit shall be equal to or less than the strength values given below.

a. For operation and control of CIR hardware equipment:
   1. Grip Strength – To remove, replace, and operate CIR hardware, grip strength required shall be less than 254 N (57 lbf).
   2. Linear Forces – Linear forces required to operate or control CIR hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 50% of the strength values shown in Figure 31 and 60% of the strength values shown in Figure 32.
   3. Torques – Torques required to operate or control CIR hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 60% of the calculated 5th percentile male capability shown in Figure 33.

b. Forces required for maintenance of CIR hardware and equipment shall be less than the 5th percentile male strength values shown in Figure 31, Figure 32, Figure 33, Figure 34, Figure 35, and Figure 36.

3.3.7.2 Adequate crew clearance.

The CIR shall provide clearance for the crew to perform installation, operations, and maintenance tasks, including clearance for hand access, tools, and equipment used in these tasks.



Arm strength (N)													
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (rad)	Pull		Push		Up		Down		In		Out	
	L**	R**	L	R	L	R	L	R	L	R	L	R
π	222	231	187	222	40	62	58	76	58	89	36	62
5/6 π	187	249	133	187	67	80	80	89	67	89	36	67
2/3 π	151	187	116	160	76	107	93	116	89	98	45	67
1/2 π	142	165	98	160	76	89	93	116	71	80	45	71
1/3 π	116	107	96	151	67	89	80	89	76	89	53	76

Hand and thumb-finger strength (N)				
	(8)		(9)	(10)
	Hand grip			
	L	R	Thumb-finger grip (Palmer)	Thumb-finger grip (tips)
Momentary hold Sustained hold	250 145	260 155	60 35	60 35

* Elbow angle shown in radians
** L = Left; R = Right

Arm strength (lb)												
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
Degree of elbow flexion (deg)	Pull		Push		Up		Down		In		Out	
	L	R*	L	R	L	R	L	R	L	R	L	R
180	50	52	42	50	9	14	13	17	13	20	8	14
150	42	56	30	42	15	18	18	20	15	20	8	15
120	34	42	26	36	17	24	21	26	20	22	10	15
90	32	37	22	36	17	20	21	26	16	18	10	16
60	26	24	22	34	15	20	18	20	17	20	12	17

Hand, and thumb-finger strength (lb)				
	(8)		(9)	(10)
	Hand grip			
	L	R	Thumb-finger grip (Palmer)	Thumb-finger grip (tips)
Momentary hold Sustained hold	56 33	59 35	13 8	13 8

* Left; R = Right

Figure 31. Arm, hand, and thumb/finger strength (5th percentile male data)

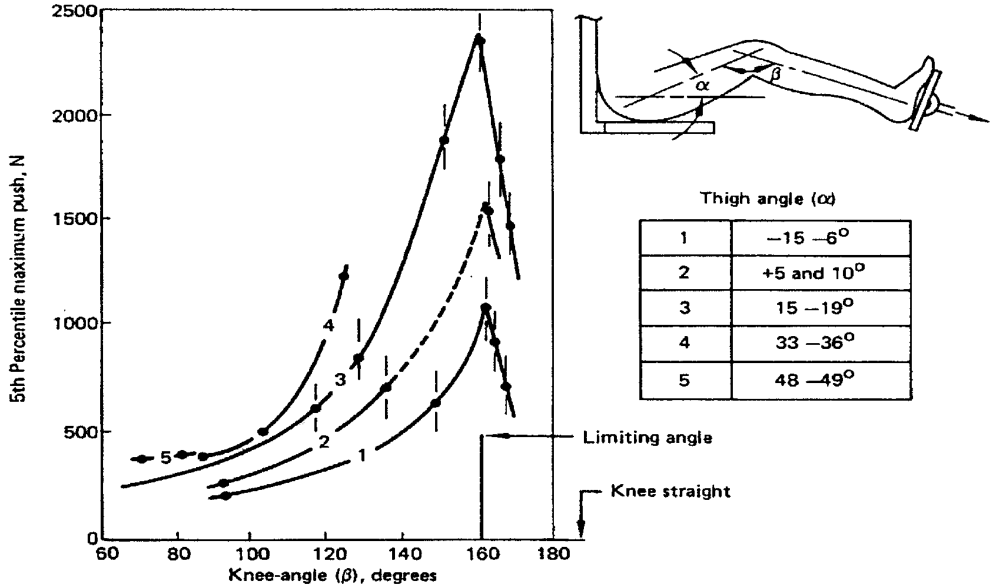


Figure 32. Leg strength at various knee and thigh angles (5th percentile male data)

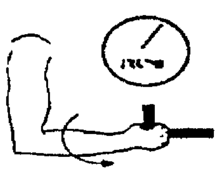
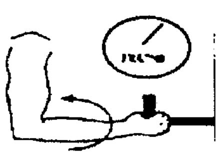
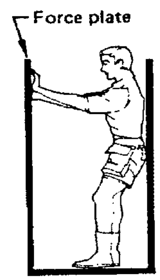
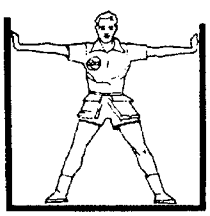
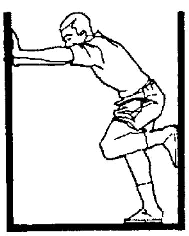
	Unpressurized suit, bare handed	
	Mean	SD
 Maximum torque: Suppination, Nm (lb-in.)	13.73 (121.5)	3.41 (30.1)
 Maximum torque: Pronation, Nm (lb-in.)	17.39 (153.9)	5.08 (45.0)

Figure 33. Torque strength

	Force-plate (1) height	Distances (2)	Force, N (lbf) Means	Force, N (lbf) SD
	100 percent of shoulder height		Both hands	
		50	583 (131)	142 (32)
		60	667 (150)	160 (36)
		70	983 (221)	271 (61)
		80	1285 (289)	400 (90)
		90	979 (220)	302 (68)
		100	645 (145)	254 (57)
			Preferred hand	
		50	262 (59)	67 (15)
		60	298 (67)	71 (16)
		70	360 (81)	98 (22)
		80	520 (117)	142 (32)
		90	494 (111)	169 (38)
		100	427 (96)	173 (39)
		Percent of thumb-tip reach *		
	100 percent of shoulder height	50	369 (83)	138 (31)
		60	347 (78)	125 (28)
		70	520 (117)	165 (37)
		80	707 (159)	191 (32)
		90	325 (73)	133 (30)
		Percent of span **		

	Force-plate (1) height	Distances (2)	Force, N (lbf) Means	Force, N (lbf) SD
	50	100	774 (174)	214 (48)
	50	120	778 (175)	165 (37)
	70	120	818 (184)	138 (31)
	Percent of shoulder height		1-g applicable data	

NOTES:

(1) Height of the center of the force plate - 200 mm (8 in) high by 254 mm (10 in) long - upon which force is applied.

(2) Horizontal distance between the vertical surface of the force plate and the opposing vertical surface (wall or footrest, respectively) against which the subject brace themselves.

() Thumb-tip reach - distance from backrest to tip of subject's thumb as thumb and fingertips are pressed together.

() Span - the maximal distance between a person's fingertips as he extends his arms and hands to each side.

(3) 1-g data.

Figure 34. Maximal static push forces

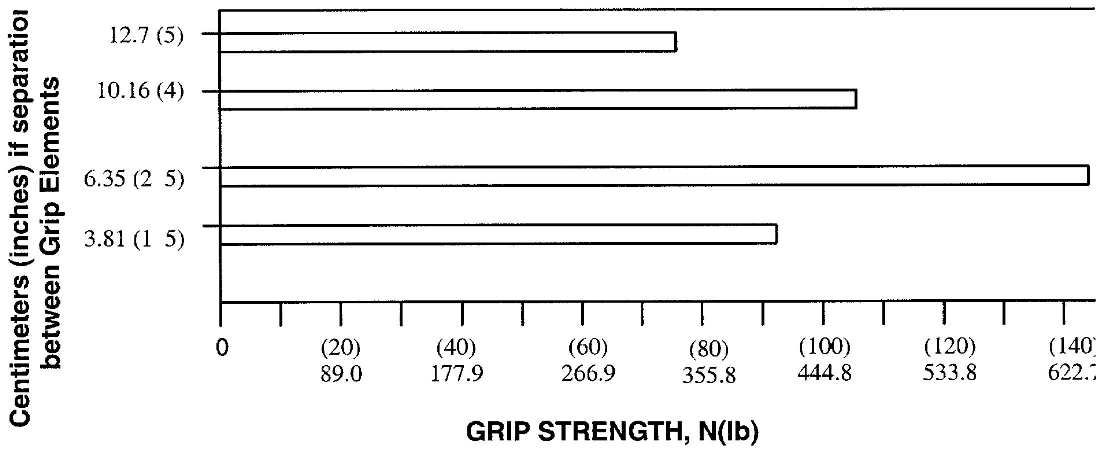


Figure 35. Male grip strength as a function of the separation between grip elements

3.3.7.3 Accessibility.

a. CIR hardware shall be geometrically arranged to provide physical and visual access for all CIR installation, operations, and maintenance tasks.
b. IVA clearances for finger access shall be provided as given in Figure 36.

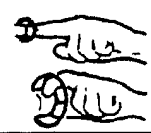
Minimal finger-access to first joint			
Push button access:	Bare hand: Thermal gloved hand:	32 mm dia (1.26 in) 38 mm dia (1.5 in)	
Two finger twist access:	Bare hand: Thermal gloved hand:	object plus 50 mm (1.97 in) object plus 65 mm (2.56 in)	

Figure 36. Minimum sizes for access openings for fingers

3.3.7.4 Full size range accommodation.

All CIR work stations and hardware having crew nominal operations and planned maintenance shall be sized to meet the functional reach limits for the 5th percentile Japanese female and yet shall not constrict or confine the body envelope for the 95th percentile American male as specified in SSP 50005, section 3.

3.3.7.5 Housekeeping closures and covers.

Closures or covers shall be provided for any area of the payload that is not designed for routine cleaning.

3.3.7.6 Built-in housekeeping control.

a. CIR containers of liquids or particulate matter shall have built-in equipment/methods for control of vaporization, material overflow, or spills.
b. The capture elements, including grids, screens, or filter surfaces shall be accessible for replacement or cleaning without dispersion of the trapped materials.

3.3.7.7 One-handed operation.

Cleaning equipment and supplies shall be designed for one-handed operation or use.

3.3.7.8 Acoustic Requirements.

3.3.7.8.1 Continuous noise limits.

The Continuous Noise Source (see Appendix B, Definitions) for the CIR (including any supporting adjunct active portable equipment operated outside the CIR that is within or interfacing with the crew habitable volume) whose sub-rack equipment will be changed out on orbit shall not, except in those cases when the rack meets the Intermittent Noise Source requirements specified in SSP 57000, paragraph 3.12.3.3.2, exceed the limits specified in Table XXII for all octave bands (NC-40 equivalent) when the equipment is operating in the loudest expected configuration and mode of operation that can occur on orbit under nominal crew, or hardware operation circumstances, during CIR setup operations, or during nominal operations where doors/panels are opened or removed.

Note: These acoustic requirements do not apply during failure or maintenance operations.

3.3.7.8.2 Intermittent noise limits.

The CIR (including any supporting adjunct active portable equipment operated outside the CIR that is within or interfacing with the crew habitable volume) Intermittent Noise Source (See Appendix B, Definitions) shall not exceed the Total Rack A-weighted SPL Limits during the Maximum Rack Noise Duration as specified in Table XXIII when the equipment is operating in the loudest expected configuration and mode of operation that can occur on orbit under any planned operations.

Note: These acoustic requirements do not apply during failure or maintenance operations.

Table XXII. Continuous noise limits

Rack Noise Limits Measured At 0.6 Meters Distance From The Test Article	
Frequency Band Hz	Integrated Rack Sound Pressure Level (SPL)
63	64
125	56
250	50
500	45
1000	41
2000	39
4000	38
8000	37

Table XXIII. Intermittent noise limits

Rack Noise Limits Measured at 0.6 meters distance from the test article	
Maximum Rack Noise Duration Ü	Total Rack A-weighted SPL (dBA)
8 Hours	49
7 Hours	50
6 Hours	51
5 Hours	52
4 Hours	54
3 Hours	57
2 Hours	60
1 Hour	65
30 Minutes	69
15 Minutes	72
5 Minutes	76
2 Minutes	78
1 Minute	79
Not Allowed	80

The Rack Noise Duration is the total time that the rack produces intermittent noise above the NC-40 limit during a 24-h time period. This duration is the governing factor in determining the allowable Intermittent Noise Limits. Regardless of the number of separate sources and varying durations within a rack, this cumulative duration shall be used to determine the A-weighted SPL limit in column B.

For example, if a rack produces 65 dBA for 30 min in a start-up and warm-up mode and then settles down to 60 dBA for a 1-h period of normal data acquisition, the duration is 1.5 h. To meet the requirement, the noise can be no greater than 60 dBA, and in this case, the rack would not meet the requirement, even though two separate payloads, one that operated at 65 dBA for 30 min and another that operated at 60 dBA for 1 h, would be acceptable (see Figure 37).

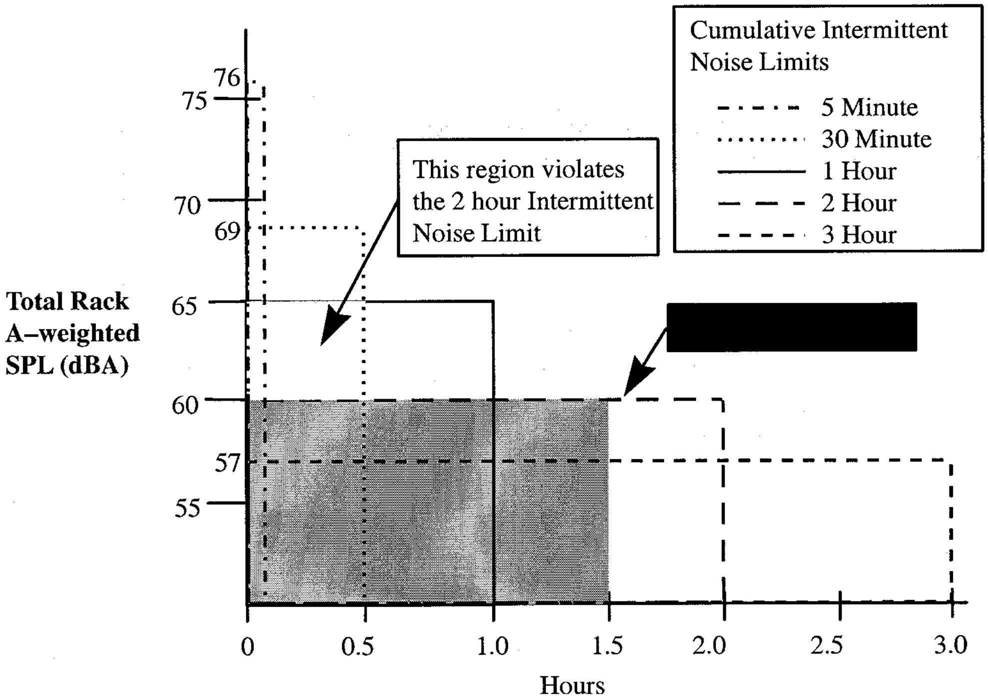


Figure 37. Intermittent noise limits

3.3.7.9 CIR hardware mounting.

3.3.7.9.1 Equipment mounting.

Equipment items used during nominal operations and planned maintenance shall be designed, labeled, or marked to protect against improper installation.

3.3.7.9.2 Drawers and hinged panel.

CIR assemblies which are pulled out of their installed positions for routine checkout shall be mounted on equipment drawers or on hinged panels. Such drawers or hinged panels shall remain in the “open” position without being supported by hand.

3.3.7.9.3 Alignment.

CIR hardware having blind mate connectors shall provide guide pins or their equivalent to assist in alignment of hardware during installation.

3.3.7.9.4 Slide-out stops.

Limit stops shall be provided on slide or pivot mounted CIR hardware which is required to be pulled out of its installed positions.

3.3.7.9.5 Push-pull force.

CIR hardware mounted into a capture-type receptacle that requires a push-pull action shall require a force less than 156 N (35 lbf) to install or remove.

3.3.7.9.6 Access.

Access to inspect or replace a hardware item (e.g., an assembly) which is planned to be accessed on a daily or weekly basis shall not require removal of another hardware item or more than one access cover.

3.3.7.9.7 Covers.

Where physical access is required, one of the following practices shall be followed, with the order of preference given:

a. Provide a sliding or hinged cap or door where debris, moisture, or other foreign materials might otherwise create a problem.
b. Provide a quick-opening cover plate if a cap will not meet stress requirements.

3.3.7.9.8 Self-supporting covers.

All access covers that are not completely removable shall be self-supporting in the open position.

3.3.7.9.9 Unique tools.

Payload provided unique tools shall meet the requirements of SSP 50005, paragraph 11.2.3.

3.3.7.10 Connectors.

3.3.7.10.1 One-handed operation.

All assembly connectors, whether operated by hand or tool, shall be designed and placed so they can be mated/demated using either hand.

3.3.7.10.2 Accessibility.

a.
   1. Nominal Operations – It shall be possible to mate/demate individual connectors without having to remove or mate/demate other connectors.

2. Maintenance Operations – It shall be possible to mate/demate individual connectors without having to remove or mate/demate connectors on other assemblies or payloads.

b. Electrical connectors and cable installations shall permit disconnection and reconnection without damage to wiring connectors.

3.3.7.10.3 Ease of disconnect.

a. Electrical connectors which are mated/demated during nominal operations shall require no more than two turns to disconnect.
b. Electrical connectors which are mated/demated only during assembly replacement operations shall require no more than six turns to disconnect.

3.3.7.10.4 Indication of pressure/flow.

CIR liquid or gas lines not equipped with quick disconnect connectors which are designed to be connected/disconnected under pressure shall be fitted with pressure/flow indicators.

3.3.7.10.5 Self locking.

Payload electrical connectors shall provide a self-locking feature.

3.3.7.10.6 Connector arrangement.

a. Space between connectors and adjacent obstructions shall be a minimum of 25 mm (1 in.) for IVA access.
b. Connectors in a single row or staggered rows which are removed sequentially by the crew (IVA) shall provide 25 mm (1 in.) of clearance from other connectors and/or adjacent obstructions for 270 degrees of sweep around each connector beginning at the start of its removal/replacement sequence.

3.3.7.10.7 Arc containment.

Electrical connector plugs shall be designed to confine/isolate the mate/demate electrical arcs or sparks.

3.3.7.10.8 Connector protection.

Protection shall be provided for all demated connectors against physical damage and contamination.

3.3.7.10.9 Connector shape.

CIR external and internal connectors shall use different connector shapes, sizes, or keying to prevent mating connectors when lines differ in content.

3.3.7.10.10 Fluid and gas line connectors.

Fluid and gas connectors that are mated and demated on orbit shall be located and configured so that they can be fully inspected for leakage.

3.3.7.10.11 Alignment marks or pin guides.

Mating parts shall have alignment marks in a visible location during mating or guide pins (or their equivalent).

3.3.7.10.12 Orientation.

Grouped plugs and receptacles shall be oriented so that the aligning pins or equivalent devices are in the same relative position.

3.3.7.10.13 Hose/cable restraints.

a. The CIR shall provide a means to restrain the loose ends of hoses and cables.
b. Conductors, bundles, or cables shall be secured by means of clamps unless they are contained in wiring ducts or cable retractors.
c. Cables shall be bundled if multiple cables are running in the same direction and the bundling does not cause electromagnetic interference (EMI).
d. Loose cables (longer than 0.33 m (1 ft) shall be restrained as follows:

Length (m)	Restraint Pattern ((% of length) tolerances +/– 10%)
0.33–1.00	50
1.00–2.00	33, 67
2.00–3.00	20, 40, 60, 80
>3.00	at least each 0.5 m

3.3.7.11 Fasteners.

3.3.7.11.1 Non-threaded fasteners status indication.

An indication of correct engagement (hooking, latch fastening, or proper positioning of interfacing parts) of non-threaded fasteners shall be provided.

3.3.7.11.2 Mounting bolt/fastener spacing.

Clearance around fasteners to permit fastener hand threading (if necessary) shall be a minimum of 0.5 in. for the entire circumference of the of the bolt head and a minimum of 1.5 in. over 180 degrees of the bolt head and provide the tool handle sweep as seen in Figure 38.

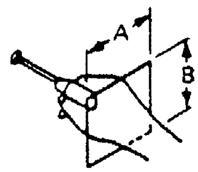
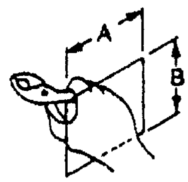
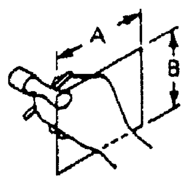
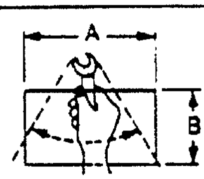
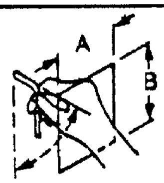
Opening dimensions	Task
 A 117 mm (4.6 in) B 107 mm (4.2 in)	Using common screw-driver with freedom to turn hand through 180°
 A 133 mm (5.2 in) B 115 mm (4.5 in)	Using pliers and similar tools
 A 155 mm (6.1 in) B 135 mm (5.3 in)	Using T-handle wrench with freedom to turn wrench through 180°
 A 203 mm (8.0 in) B 135 mm (5.3 in)	Using open-end wrench with freedom to turn wrench through 62°
 A 122 mm (4.8 in) B 155 mm (6.1 in)	Using Allen-type wrench with freedom to turn wrench through 62°

Figure 38. Minimal clearance for tool-operated fasteners

3.3.7.11.3 Multiple fasteners.

When several fasteners are used on one item they shall be of identical type.

3.3.7.11.4 Captive fasteners.

All fasteners planned to be installed and/or removed on orbit shall be captive when disengaged.

3.3.7.11.5 Quick release fasteners.

a. Quick release fasteners shall require a maximum of one complete turn to operate (quarter-turn fasteners are preferred).
b. Quick release fasteners shall be positive locking in open and closed positions.

3.3.7.11.6 Threaded fasteners.

Only right-handed threads shall be used.

3.3.7.11.7 Over center latches.

a. Non-self-latching – Over center latches shall include a provision to prevent undesired latch element realignment, interface, or reengagement.
b. Latch lock – Latch catches shall have locking features.
c. Latch handles – If the latch has a handle, the latch handle and latch release shall be operable by one hand.

3.3.7.11.8 Winghead fasteners.

Winghead fasteners shall fold down and be retained flush with surfaces.

3.3.7.11.9 Fastener head type.

a. Hex type external or internal grip or combination head fasteners shall be used where on orbit crew actuation is planned, e.g., assembly replacement.
b. If a smooth surface is required, flush or oval head internal hex grip fasteners shall be used for fastening.
c. Slotted fasteners shall not be used to carry launch loads for hard-mounted equipment. Slotted fasteners are allowed in non-structural applications (e.g., computer data connectors, stowed commercial equipment).
   Note: Phillips or Torque-Set fasteners may be used where fastener installation is permanent relative to planned on orbit operations or maintenance, or where tool-fastener interface failure can be corrected by replacement of the unit containing the affected fastener with a spare unit.

3.3.7.11.10 One handed operation.

Fasteners planned to be removed or installed on orbit shall be designed and placed so they can be mated/demated using either hand.

3.3.7.11.11 Access holes.

Covers or shields though which mounting fasteners must pass for attachment to the basic chassis of the unit shall have holes for passage of the fastener without precise alignment (and hand or necessary tool if either is required to replace).

3.3.7.12 Controls and displays.

3.3.7.12.1 Controls spacing design requirements.

All spacing between controls and adjacent obstructions shall meet the minimum requirements as shown in Figure 39.

3.3.7.12.2 Accidental actuation.

3.3.7.12.2.1 Protective methods.

The CIR shall provide protection against accidental control actuation using one or more of the protective methods listed in subparagraphs a though g below. Infrequently used controls (i.e. those used for calibration) should be separated from frequently used controls. Leverlock switches or switch covers are strongly recommended for switches related to mission success. Switch guards may not be sufficient to prevent accidental actuation.

Note: Displays and controls used only for maintenance and adjustments, which could disrupt normal operations if activated, should be protected during normal operations, e.g., by being located separately or guarded/covered.

a. Locate and orient the controls so that the operator is not likely to strike or move them accidentally in the normal sequence of control movements.
b. Recess, shield, or otherwise surround the controls by physical barriers. The control shall be entirely contained within the envelope described by the recess or barrier.
c. Cover or guard the controls. Safety or lock wire shall not be used.
d. Cover guards when open shall not cover or obscure the protected control or adjacent controls.
e. Provide the controls with interlocks so that extra movement (e.g., lifting switch out of a locked detent position) or the prior operation of a related or locking control is required.
f. Provide the controls with resistance (i.e., viscous or coulomb friction, spring-loading, or inertia) so that definite or sustained effort is required for actuation.
g. Provide the controls with a lock to prevent the control from passing though a position without delay when strict sequential actuation is necessary (i.e., the control moved only to the next position, then delayed).

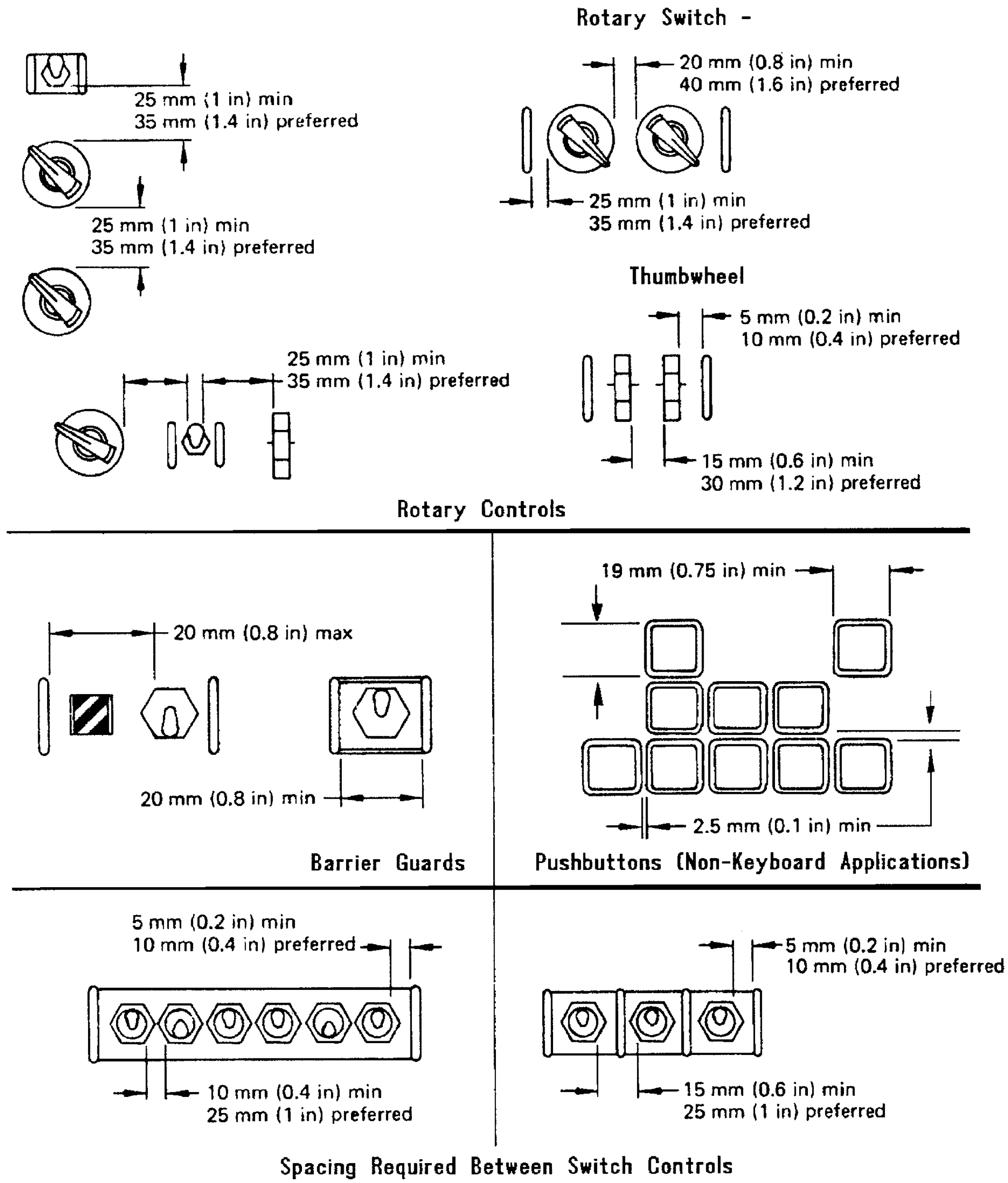


Figure 39. Control spacing requirements for ungloved operation

3.3.7.12.2.2 Noninterference.

CIR provided protective devices shall not cover or obscure other displays or controls.

3.3.7.12.2.3 Dead-man controls.

Dead-man controls shall be as specified in NSTS 1700.7 ISS Addendum, paragraphs 200.4 a. and 303.2.

3.3.7.12.2.4 Barrier guards.

Barrier guard spacing shall adhere to the requirements for use with the toggle switches, rotary switches, and thumbwheels as shown in Figure 39 and Figure 40.

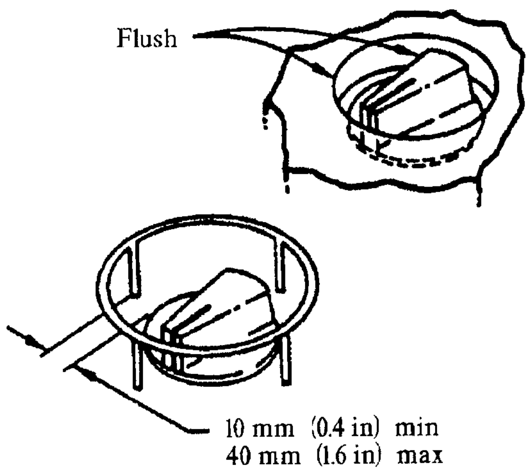


Figure 40. Rotary switch guard

3.3.7.12.2.5 Recessed switch protection.

When a barrier guard is not used, rotary switches that control critical functions shall be recessed as shown in Figure 40.

3.3.7.12.2.6 Position indication.

When CIR switch protective covers are used, control position shall be evident without requiring cover removal.

3.3.7.12.2.7 Hidden controls.

Controls that cannot be directly viewed will be avoided. If present, hidden controls shall be guarded to protect against inadvertent actuation.

3.3.7.12.2.8 Hand controllers.

Hand controllers, excluding trackballs and mice, shall have a separate on/off control to prevent inadvertent actuation when the controller is not in use.

3.3.7.13 Valve controls.

a. Low-Torque Valves – Valves requiring 1 N-m (10 in-lb) or less for operation are classified as “low-torque” valves and shall be provided with a “central pivot” type handle, 5.5 cm (2.25 in.) or less in diameter. (see 3.3.7.13 d.).
b. Intermediate-Torque Valves – Valves requiring between 1 and 2 N-m (10 and 20 in-lb) for operation are classified as “intermediate torque” valves and shall be provided with a “central pivot” type handle, 5.5 cm (2.25 in.) or greater in diameter, or a “lever type” handle, 7.5 cm (3 in.) or greater in length.
c. High-Torque Valves – Valves requiring 2 N-m (20 in-lb) or more for operation are classified as “high-torque” valves and shall be provided “lever type” handles greater than 7.5 cm (3 in.) or greater in length.
d. Handle Dimensions – Valve handles shall adhere to the clearances and dimensions illustrated in Figure 41 and Figure 42.
e. Rotary Valve Controls – Rotary valve controls shall open the valve with a counterclockwise motion.

3.3.7.14 Toggle switches.

Dimensions for a standard toggle switch shall conform to the values presented in Figure 43.

3.3.7.15 Restraints and mobility aids.

The CIR shall be designed such that all installation, operation, and maintenance can be performed using standard crew restraints, mobility aids, and interfaces as defined in SSP 30257:004.

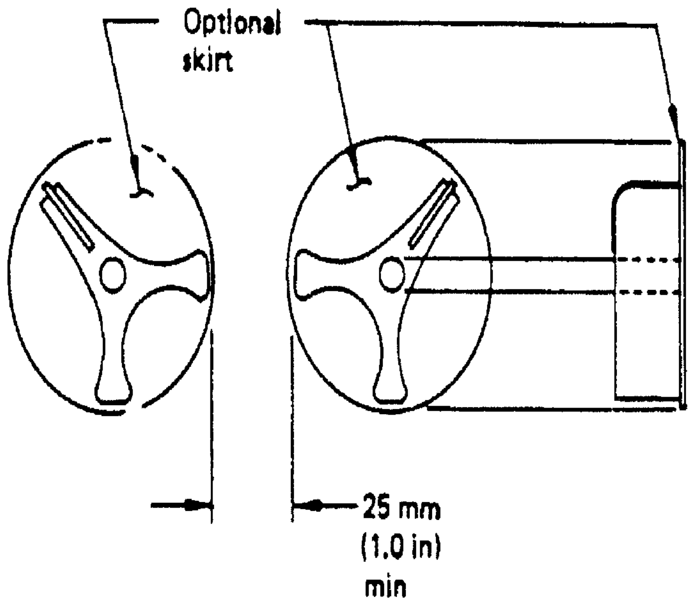


Figure 41. Valve handle – central pivot type

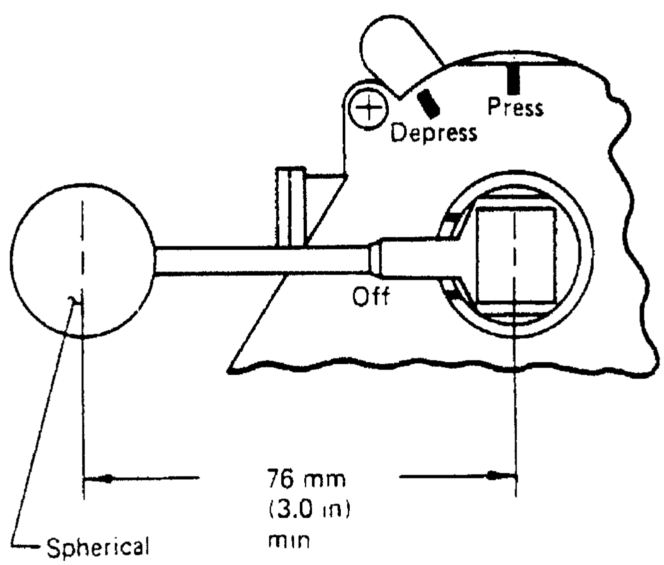
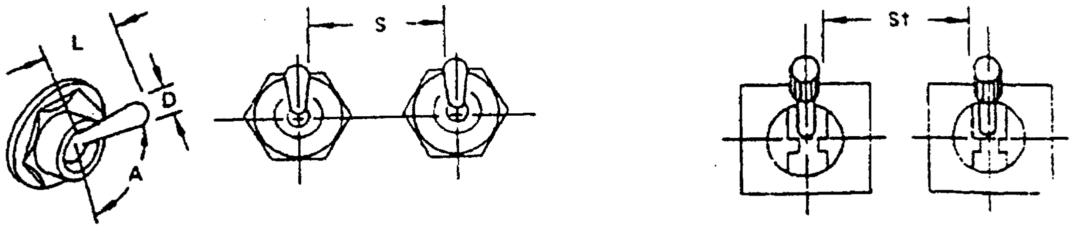


Figure 42. Valve handle – lever type



	Dimensions		Resistance	
	L Arm length	D Control tip	Small switch	Large switch
Minimum	13 mm (1/2 in)	3mm (1/8 in)	2.8 N (10 oz)	2.8 N (10 oz)
Maximum	50 mm (2 in)	25 mm (1 in)	4.5 N (16 oz)	11 N (40 oz)

	Displacement between positions A	
	2 position	3 position
Minimum	30°	17°
Maximum	80°	40°
Desired		25°

	Separation S			
	Single finger operation	†	Single finger sequential operation	Simultaneous operation by different fingers
Minimum	19 mm (3/4 in)	25 mm (1 in)	13 mm (1/2 in)	16 mm (5/8 in)
Optimum	50 mm (2 in)	50 mm (2 in)	25 mm (1 in)	19 mm (3/4 in)

† Using a lever lock toggle switch

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Reference: 2, page 93

Figure 43. Toggle switches

3.3.7.16 Captive parts.

The CIR equipment shall be designed in such a manner to ensure that all unrestrained parts (e.g., locking pins, knobs, handles, lens covers, access plates, or similar devices) that may be temporarily removed on orbit will be tethered or otherwise held captive.

3.3.7.17 Handle and grasp area design requirements.

3.3.7.17.1 Handles and restraints.

All removable or portable items which cannot be grasped with one hand shall be provided with handles or other suitable means of grasping, tethering, carrying, and restraining.

3.3.7.17.2 Handle location/front access.

Handles and grasp areas shall be placed on the accessible surface of a payload item consistent with the removal direction.

3.3.7.17.3 Handle dimensions.

IVA handles for movable or portable units shall be designed in accordance with the minimum applicable dimensions in Figure 44.

3.3.7.17.4 Nonfixed handles design requirements.

a. Nonfixed handles shall have a stop position for holding the handle perpendicular to the surface on which it is mounted.
b. Nonfixed handles shall be capable of being placed in the use position by one hand and shall be capable of being removed or stowed with one hand.
   Attachable/removable handles shall incorporate tactile and/or visual indication of locked/unlocked status.

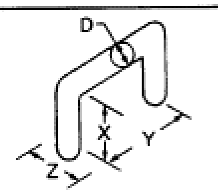
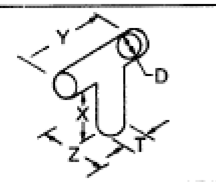
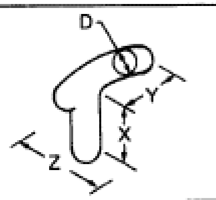
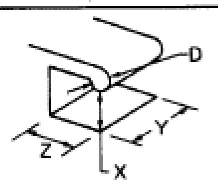
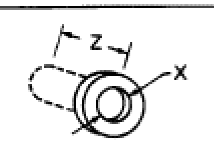
Illustration	Type of handle	Dimensions in mm (in inches)		
		(Bare hand)		
		X	Y	Z
 	Two-finger bar One-hand bar Two-hand bar	32 (1–1/4) 48 (1–7/8) 48 (1–7/8)	65 (2–1/2) 111 (4–3/8) 215 (8–1/2)	75 (3) 75 (3) 75 (3)
 	T-bar	38 (1–1/2)	100 (4)	75 (3)
 	J-bar	50 (2)	100 (4)	75 (3)
 	Two-finger recess One-hand recess	32 (1–1/4) 50 (2)	65 (2–1/2) 110 (4–1/4)	75 (3) 90 (3–1/2)
 	Finger-tip recess One-finger recess	19 (3/4) 32 (1–1/4)	– –	13 (1/2) 50 (2)
Curvature of handle or edge (DOES NOT PRECLUDE USE OF OVAL HANDLES)	Weight of Item Up to 6.8 kg (up to 15 lbs) 6.8 to 9.0 kg (15 to 20 lbs) 9.0 to 18 kg (20 to 40 lbs) Over 18 kg (over 40 lbs) T-bar post	Minimum diameter D = 6 mm (1/4 in) D = 13 mm (1/2 in) D = 19 mm (3/4 in) D = 25 mm (1 in) T = 13 mm (1/2 in)	Gripping efficiency is best if finger can curl around handle or edge to any angle of 2/3 π rad (120°) or more	

Figure 44. Minimum IVA handle dimensions for IVA applications

3.3.8 Design requirements.

3.3.8.1 Units of measure.

The CIR shall use metric units as its primary unit of measure, except when interfacing with non-metric ISS equipment or lack of availability of metric components precludes it.

3.3.8.2 Margins of safety/factor of safety.

The design of the CIR shall use factors of safety as specified in NSTS 1700.7, NSTS 1700.7 ISS Addendum, and SSP 52005.

3.3.8.3 Allowable mechanical properties.

Values for mechanical properties of structural materials in their design environment shall be taken in accordance with MIL-HDBK-05 and MIL-HDBK-27 using the "A" allowable.

3.3.8.4 Fracture control.

The CIR structure shall meet the fracture control requirements as specified in NASA-STD-5003.

3.3.8.5 End-of-life decommissioning and disposal.

The CIR shall be designed to be capable of disassembly and disposal for the purpose of decommissioning according to federal, state, and local laws.

3.4 CIR computer resource requirements.

In addition to the computer resource requirements specified in paragraph 3.2, the CIR shall meet the requirements in this section.

3.4.1 CIR computer software design considerations.

a. The CIR primary processor shall be capable of self-activation and self-test once power is applied to the CIR power interface.
b. The CIR shall verify the integrity of all transmitted files.
c. A single computer within the CIR shall coordinate all automated activities performed by the CIR.
d. The CIR shall use CAN bus for command and control and for health and status data collection.
e. The CIR shall use fiber optics for transferring all digital image data and inter-rack communications.
f. All CIR avionics (hardware and software) shall be designed to mitigate the consequences of Single Event Effects (SEE).

3.4.1.1 Command and data requirements.

3.4.1.1.1 Word/byte notations.

The CIR shall use the word/byte notations as specified in SSP 52050, paragraph 3.1.1.

3.4.1.1.2 Data types.

The CIR shall use the data types as specified in SSP 52050, paragraph 3.2.1 and subparagraphs.

3.4.1.1.3 Data transmissions.

a. The CIR data transmission on low rate data link (LRDL), MIL-STD-1553B shall use the data transmission order in accordance with D684-10056-01, paragraph 3.4.
b. The CIR data transmission on medium rate data link (MRDL) shall use the data transmission order in accordance with SSP 52050, paragraph 3.3.3.1.
c. The CIR data transmission on high rate data link (HDRL) shall use the data transmission order in accordance with CCSDS 701.0-B-2, paragraph 1.6.

3.4.1.1.4 Consultative committee for space data systems.

a. CIR data that is space to ground shall be Consultative Committee for Space Data Systems (CCSDS) data packets.
b. CIR data that is ground to space shall be CCSDS data packets.
c. CIR to Payload MDM data shall be CCSDS data packets.

3.4.1.1.4.1 CCSDS data packets.

CIR data packets shall be developed in accordance with SSP 52050, paragraph 3.1.3. CIR CCSDS data packets consist of a primary header and a secondary header followed by the data field.

3.4.1.1.4.1.1 CCSDS primary header.

CIR shall develop a CCSDS primary header in accordance with SSP 52050, paragraph 3.1.3.1.

3.4.1.1.4.1.2 CCSDS secondary header.

a. The CIR shall develop a CCSDS secondary header immediately following the CCSDS primary header.
b. The CCSDS secondary header shall be developed in accordance with SSP 52050, paragraph 3.1.3.2.

3.4.1.1.4.1.3 CCSDS data field.

The CIR CCSDS data field shall contain the CIR data from the transmitting application to the receiving application, and the CCSDS checksum in accordance with SSP 52050, paragraph 3.1 and subparagraphs.

3.4.1.1.4.1.4 CCSDS application process identification field.

The CCSDS application process identification (APID) shall be used for routing data packets as described in SSP 41175-2, paragraph 3.3.2.1.3. The format of APID is shown in SSP 41175-2, Table 3.3.2.1.1–1.

3.4.1.1.4.2 CCSDS time codes.

3.4.1.1.4.2.1 CCSDS unsegmented time.

CIR shall use CCSDS unsegmented time code (CUC) in the secondary header as specified in CCSDS 301.0-B-2, paragraph 2.2.

3.4.1.1.4.2.2 CCSDS segmented time.

Segmented time code shall be sent to the integrated rack by a broadcast message on the Payload MIL-STD-1553B. Segmented time code formats are specified in CCSDS 301.0-B-2, paragraph 2.4.

The broadcast time will be received at subaddress #29 on each Payload MIL-STD-1553B bus.

3.4.1.1.5 MIL-STD-1553B low rate data link (LRDL).

The CIR shall implement a single MIL-STD-1553B Remote Terminal (RT) to the payload unique MIL-STD-1553B bus in accordance with SSP 52050, paragraph 3.2.

3.4.1.1.5.1 Standard messages.

The CIR shall develop standard messages for the Payload MIL-STD-1553B in accordance with SSP 52050, paragraph 3.2.3.3.

3.4.1.1.5.2 Commanding.

The CIR shall receive and process commands from the Payload MDM that originate from the Ground, Timeliner, Payload MDM, and Portable Computer System (PCS) in accordance with SSP 52050, paragraph 3.2.3.4.

3.4.1.1.5.3 Health and status data.

a. The CIR shall develop health and status data in accordance with SSP 52050, paragraph 3.2.3.5.
b. The health and status data shall be documented in accordance with the data field format defined in SSP 57002, Table A–5. The definition of health and status data is provided in the Definitions, Appendix B of this document.
c. The CIR shall respond to its respective CIR MDM polls for health and status data with updated data at a 1 or 0.1 Hz rate.

3.4.1.1.5.4 Safety data.

a. Safety data shall be included in the health and safety data CCSDS packets provided by ISPR RT's.
b. The CIR shall provide as safety data the standard rack caution and warning status words in accordance with SSP 52050, paragraph 3.2.3.5.

3.4.1.1.5.5 Caution and warning.

3.4.1.1.5.5.1 Class 2 – warning.

The CIR shall format the caution and warning word in accordance with SSP 52050, paragraph 3.2.3.5 as a warning when the CIR sensors detect the following conditions:

1. A potential fire event, (detected by a sensor other than an ISS rack smoke detector or equivalent).
   h. A precursor event that could manifest to an emergency condition (toxic atmosphere, rapid cabin depressurization or fire) and
   a. Automatic safing has failed to safe the event or
   b. The system is not automatically safed (i.e. requires manual intervention).
   i. An event that results in the loss of a hazard control and
   a. Automatic safing has failed to safe the event or
   b. The system is not automatically safed (i.e. requires manual intervention).

Note: A warning requires someone to take action immediately. Warnings are used for events that require manual intervention and for notification when automatic safing fails.

3.4.1.1.5.5.2 Class 3 – caution.

The CIR shall format the caution and warning word in accordance with SSP 52050, paragraph 3.2.3.5 as a caution when the CIR sensors detect the following conditions:

1. A precursor event that could manifest to an emergency condition (toxic atmosphere, rapid cabin depressurization, or fire) and automatic safing has safed the event (i.e. the system does not require manual intervention).
2. An event that results in the loss of a hazard control and automatic safing has safed the event (i.e., the system does not require manual intervention).

Note: A caution requires no immediate action by the crew. Automatic safing has controlled the event.

3.4.1.1.5.5.3 Class 4 – advisory.

The CIR shall format the caution and warning word in accordance with SSP 52050, paragraph 3.2.3.5 as an advisory. Advisories are set for the following conditions:

1. Advisories are set primarily for ground monitoring purposes (advantageous due to limited comm. coverage and data recording).
2. Data item that most likely will not exist permanently in Telemetry List but should be time tagged and logged for failure isolation, trending, sustaining engineering, etc.

3.4.1.1.5.6 Service requests.

The CIR shall develop service requests that shall be in accordance with SSP 52050, paragraph 3.2.3.7. The service requests data format shall be developed in accordance with SSP 52050, Table 3.2.3.7–1.

3.4.1.1.5.7 File transfer.

The CIR shall develop its file transfer in accordance with SSP 52050, paragraph 3.2.3.9.

3.4.1.1.5.8 Low rate telemetry.

The CIR shall develop low rate telemetry (i.e. science data) in accordance with SSP 52050, paragraph 3.2.3.10.

3.4.1.1.5.9 Defined mode codes.

CIR MIL-STD-1553B shall use the mode codes as specified in SSP 52050, paragraph 3.2.3.2.1.5.

3.4.1.1.5.10 Implemented mode codes.

The CIR MIL-STD-1553B Remote Terminal (RT) may be designed to recognize both unimplemented and undefined mode codes as illegal commands. If the RT designer does decide to monitor for unimplemented/undefined code modes, the RT shall respond by setting the message error bit in the status word.

3.4.1.1.5.11 Illegal commands.

The CIR MIL-STD-1553B RT’s are not required to respond to illegal commands. If an RT designed with this option detects an illegal command, it shall respond to the illegal command by setting the message error bit in the status word.

3.4.1.1.5.12 LRDL interface characteristics.

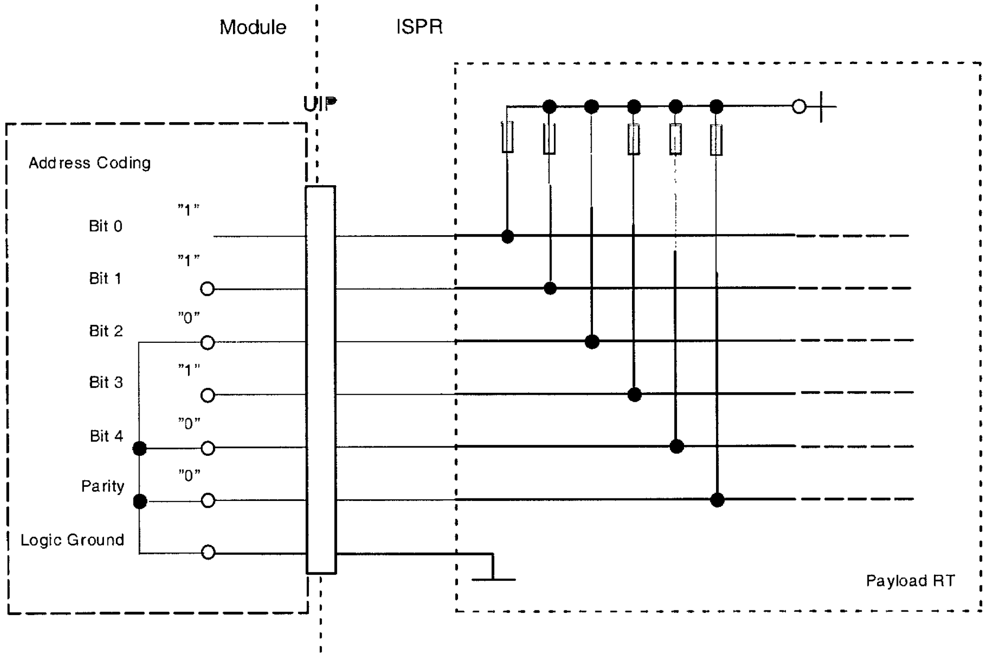
a. CIR connectors P3 and P4 shall meet the pinout interfaces of the UIP J3 and J4 connectors respectively as specified in SSP 57001, paragraph 3.3.2.2.
b. CIR connectors P3 and P4 shall meet the requirements of SSQ 21635 or equivalent.

3.4.1.1.5.12.1 Remote terminal hardwired address coding.

a. The CIR shall be designed to read and respond to the hardware Remote Terminal address coding scheme for the Standard Payload Bus, for all ISPR locations defined in Table XXIV. Details of the implementation of the payload Remote Terminals are illustrated in Figure 45.
b. Decimal values shall be mapped in 5 bit presentation, bit 0 = Least Significant Bit (LSB), see Figure 45.
c. Odd-parity shall be used.
d. Jumpering address line to ground shall be logic 0.
e. Pull up devices, shown in Figure 45, shall be in accordance with MIL-STD-1553B.

Table XXIV. Remote terminal hardwired address coding for standard payload bus

APM ISPR		JEM ISPR		USL ISPR		CAM ISPR	
Location	RT Hardwired Address	Location	RT Hardwired Address	Location	RT Hardwired Address	Location	RT Hardwired Address
APM1F1	15	JPM1F1	15	LAB101	8	CAM1F2 (TBC)	20
APM1F2	16	JPM1F2	16	LAB102	9	CAM1F3 (TBC)	21
APM1F3	17	JPM1F3	17	LAB103	10	CAM1A2 (TBC)	20
APM1F4	18	JPM1F5	18	LAB104	11	CAM1A3 (TBC)	21
APM1A1	19	JPM1F6	19	LAB105	12	CAM1A3 (TBC)	**(TBD #9)**
APM1A2	20	JPM1A1	20	LAB1S1	8		
APM1A3	21	JPM1A2	21	LAB1S2	9		
APM1A4	22	JPM1A3	22	LAB1S3	10		
APM101	23	JPM1A4	23	LAB1S4	11		
APM102	24	JPM1A5	24	LAB1D3	14		
				LAB1P1	12		
				LAB1P2	15		
				LAB1P4	17		



Note: Example RT Address = 11 in decimal representation.
All address and parity lines have pull up resistors so that "0" on those lines is achieved by connecting the lines to common secondary return. The parity is odd. Bit 0 is LSB.

Figure 45. Remote terminal hardwired address coding example

3.4.1.1.5.12.2 LRDL signal characteristics.

a. The CIR shall meet the electrical characteristics in accordance with MIL-STD-1553B.
b. The CIR MIL-STD-1553B terminal characteristics shall be in accordance with MIL-STD-1553B, paragraph 4.5.2.

3.4.1.1.5.12.3 LRDL cabling.

a. The CIR MIL-STD-1553B internal wiring characteristics shall be according to SSQ 21655 for 75 Ω or equivalent.
b. The CIR MIL-STD-1553B internal wiring characteristics are summarized in MIL-STD-1553B, Table 3.3.5.2.3–1.
c. The CIR MIL-STD-1553B internal wiring stub length shall not exceed 12 ft (3.65 m) when measured from the internal MIL-STD-1553B Remote Terminal to the ISPR Utility Interface Panel.

Table XXV. MIL-STD-1553B network characteristics

Characteristic	Parameter
Type	Twisted Shielded Pair SSQ 21655 or Equivalent
Characteristic Impedance	75 ± 5 Ohm
Cable Size	22 AWG or 24 AWG
Nominal wire-to-wire Capacitance	66 pf/m

3.4.1.1.5.12.4 Multi-bus isolation.

The signal isolation between multiple ISS Payload MIL-STD-1553B data buses shall be no less than 58 dB.

3.4.1.1.6 Medium rate data link (MRDL).

3.4.1.1.6.1 MRDL protocol.

The CIR shall conform with ISO/IEC 8802-3 10-Base-T protocol in accordance with SSP 52050, paragraph 3.3.

3.4.1.1.6.2 CIR protocols on the MRDL.

a. The CIR shall conform with ISO/IEC 8802-3 10-Base-T protocol in accordance with SSP 52050, paragraph 3.3.
b. The CIR shall use the CCSDS protocol and gateway protocol in SSP 52050, paragraphs 3.3.4 and 3.3.7.

3.4.1.1.6.3 MRDL address.

a. The CIR shall have a unique Institute of Electrical and Electronic Engineers (IEEE) issued physical address.
b. The unique address shall be set prior to the Ethernet terminal going active. The CIR will indicate the unique physical address in the SSP 57217.

3.4.1.1.6.4 CIR MRDL connectivity.

a. The CIR with an MRDL connection shall have no more than one physical connection per LAN. An integrated rack with an MRDL connection may have one physical connection to LAN-1 and one physical connection to LAN-2. LAN-1 is located in J46 and LAN-2 is located in J47.
b. The CIR shall not route or transmit the same MRDL message to the ISS LAN’s simultaneously.

c. The CIR with internal MRDL(s) shall provide isolation between the ISS MRDL LAN's and the internal LAN's with either an Ethernet Bridge or an Internet Protocol router that connects the LAN-1 and LAN-2 to the internal rack LAN(s).
d. The Ethernet device connected to the ISS LAN shall have a (unique) IEEE issued address.

3.4.1.1.6.5 MRDL connector/pin assignments and wire requirements.

a. The CIR connectors P46 and P47 shall meet the pinout interfaces of the UIP J46 and J47 connectors as specified in SSP 57001, paragraph 3.3.3.1.
b. CIR LAN-1 and LAN-2 connectors P46 and P47 shall meet the requirements of SSQ 21635 or equivalent.
c. CIR LAN-1 and LAN-2 wires shall meet the requirements of 100 Ω twisted-pair per SSQ 21655 or equivalent. The 100 Ω twisted shielded pair cable defined in SSQ 21655 must be used due to its characteristics at MRDL data transmission frequencies.

3.4.1.1.6.6 MRDL signal characteristics.

The CIR shall meet the electrical characteristics of MRDL in accordance with ISO/IEC 8802-3 with the following exceptions:

IEC Publication	60	High-Voltage Test Techniques
IEC Publication	380	Safety of Electrically Energized Office Machines
IEC Publication	435	Safety of Data Processing Equipment
IEC Publication	950	Safety of Information Technology Equipment, Including Electrical Business Equipment

3.4.1.1.6.7 MRDL cable characteristics.

The MDRL cable characteristics shall be as given in Table XXVI.

Table XXVI. Link segment cable characteristics

Characteristic	Parameter
Characteristic Impedance	100 ±7 Ohm
Cable Size	22 AWG
Type of Cable	Twisted Shielded Pair SSQ 21655 or Equivalent
Nominal wire-to-wire Capacitance	45 pF/m
Max Cable Length in ISPR	5 m

3.4.1.1.6.7.1 Differential characteristic impedance.

The ISPR differential characteristic impedance shall meet the requirements specified in ISO/IEC 8802-3, paragraph 14.4.2.2 with the exception that the wire meets the performance characteristics in Table XXVII.

Table XXVII. NTSC video performance characteristics.

Characteristic	End-to-End Path Characteristics	Test Method
Amplitude vs. Frequency	10 KHz to 300 KHz: ±0.2 dB at 3.58 Mhz ± 300 Khz :±0.4 dB to 4.2 Mhz: ±0.7 dB (A) to 10 Mhz: +1/–3 dB	EIA/TIA – 250C Para 6.1.1
Chrominance to Luminance Gain Inequality	± 4.0 IRE units	EIA/TIA – 250C Para 6.1.2.1
Chrominance to Luminance Delay Inequality	± 26 ns	EIA/TIA – 250C Para 6.1.2.2
Field Time Waveform Distortion	3 IRE units peak-to-peak	EIA/TIA – 250C Para 6.1.4
Line Time Waveform Distortion	1 IRE unit peak-to-peak	EIA/TIA – 250C Para 6.1.5
Short Time Waveform Distortion	2.0%	EIA/TIA – 250C Para 6.1.1
Long Time Waveform Distortion	8 IRE units overshoot Max. setting to 5 IRE units after 3 Sec.	EIA/TIA – 250C Para 6.1.7
Line-By-Line DC Offset	± 2.0 IRE Max.	
Insertion Gain and Variation	± 0.2 dB	EIA/TIA – 250C Para 6.1.8
Luminance Non-Linearity	6% Max	EIA/TIA – 250C Para 6.2.1
Differential Gain	4% Max	EIA/TIA – 250C Para 6.2.2.1
Differential Phase	1.9 degrees	EIA/TIA – 250C Para 6.2.2.2
Chrominance to Luminance Intermodulation	2.0 IRE	EIA/TIA – 250C Para 6.2.3
Chrominance Non-Linear Gain	2.0 IRE	EIA/TIA – 250C Para 6.2.4.1
Chrominance Non-Linear Phase	2.0 degrees	EIA/TIA – 250C Para 6.2.4.2
Dynamic Gain of the Picture Signal	4.0 IRE	EIA/TIA – 250C Para 6.2.5.1
Dynamic Gain of the Synchronizing Signal	2.0 IRE	EIA/TIA – 250C Para 6.2.5.2
Transient Synchronizing Signal Non-Linearity	3.0 IRE	EIA/TIA – 250C Para 6.2.6
Signal to Noise Ratio (10 KHz to 5 MHz) (Triangular)	43.8 dB min, unweighted	EIA/TIA – 250C Para 6.3.1
Signal to Noise Ratio (10 KHz to 10 MHz) (Triangular)	36.6 dB min, unweighted	EIA/TIA – 250C Para 6.3.1
Signal to Low Frequency Noise (0–10 kHz)	50 dB min, unweighted	EIA/TIA – 250C Para 6.3.2
Signal to Periodic Noise Ratio (300 Hz to 4.2 MHz)	63 dB min, unweighted	EIA/TIA – 250C Para 6.3.3
2T Short Time Distortion	± 4.0 IRE units	NTC–7 Para 3.5
Group Delay (5 to 10 MHz)	150 ns	

Note

(A) Monotonic roll off beyond 4.2 Min MHz.

3.4.1.1.7 CIR to high-rate frame multiplexer (HFM) protocols.

The CIR shall use the HFM common protocols in accordance with SSP 50184, paragraph 3.3.2.

3.4.1.1.7.1 High rate data link (HDRL) physical signaling data rates.

a. The CIR shall be designed to transmit data on the HDRL with adjustable data rates in between 0.5 and 95 Mbps.
b. The CIR HDRL data rate shall be adjustable in increments of 0.5 Mbps.
c. Transmitted data shall be designed to be “evenly parsed” in accordance with SSP 50184, paragraph 3.3.1.3.2.

Note:

1. The HDRL is a shared resource on the ISS. The HDRL data is sent to the ground though the HFM. When a payload has the entire HFM capacity assigned to that payload, the Maximum HDRL data rate is approximately 43 Mbps. Under normal conditions the payload shares the 43 Mbps with 11 other data sources. The actual HDRL data rate designed into the payload is subject to planning.
2. The CIR maximum designed data rate is subject to planning.
3. The CIR is not required to implement every possible increment in the negotiated range. For example, an integrated rack may choose to implement 0.5, 1.0, 2.0, 4.0, 8.0, and 16.0 Mbps for a planned range of 0.5 to 16.0 Mbps.
4. The data rate tolerance is under investigation.
5. The CIR may use any HDRL data rate desired in a multi-location payload where the source payload and the destination payload for the HDRL data is developed by one payload project.

3.4.1.1.7.2 Encoding.

The CIR shall encode the HDRL data in accordance with SSP 50184, paragraph 3.1.3; SSP 50184, paragraph 3.1.3.1; SSP 50184, Table 3.1.3.1–1; and SSP 50184, paragraph 3.1.3.2.

3.4.1.1.7.3 CIR HDRL transmitted optical power.

a. The CIR shall be designed to transmit a HDRL signal in accordance with SSP 50184, paragraph 3.1.1 at an average optical power greater than -16.75 dBm and less than -8.3 dBm.
b. The CIR transmitted optical power shall be measured at the CIR P7 connector to the ISPR connector interface panel using the Halt symbol.

3.4.1.1.7.4 HDRL fiber optic cable.

The CIR shall use fiber optic cable in accordance with SSQ 21654.

3.4.1.1.7.5 HDRL fiber optic bend radius.

The CIR shall develop the routing, installation, and handling procedures to assure the minimum bend radius of 2 in. or greater is maintained at all times for the fiber optic cable.

3.4.1.1.7.6 HDRL connectors and fiber.

a. The CIR connector P7 shall meet the pinout interfaces of the UIP J7 connector as specified in SSP 57001, paragraph 3.3.4.1.
b. The CIR HDRL connector P7 shall meet the requirements of SSQ 21635 or equivalent.
c. The CIR HDRL fiber shall meet the requirements of SSQ 21654 or equivalent.

3.4.1.1.8 Station support computer (SSC).

a. The CIR shall be limited to one shared SSC. The SSC is not dedicated to a rack; memory and hard drive availability for payload displays and software must be negotiated with the Payload Software Control Panel.
b. SSC displays shall be in accordance with SSP 50313 (not unique to SSC).

3.4.1.1.9 CIR national television systems committee (NTSC) video and audio interface requirements.

3.4.1.1.9.1 CIR NTSC video characteristics.

a. CIR NTSC video characteristics shall be in accordance with Table XXVII.
b. The interpretation shall be in accordance with EIA/TIA RS-250-C End to End NTSC Video for Satellite Transmission System.
c. Video signal to crosstalk noise shall be in accordance with NTC-7, paragraph 3.19.

3.4.1.1.9.2 Pulse frequency modulation NTSC fiber optic video characteristics.

a. The pulsed frequency modulation (PFM) fiber optic video shall be in accordance with paragraph 3.4.1.1.9.1.
b. The PFM fiber optic characteristics shall be in accordance with Table XXVIII.

Notes:
1. Or any video/data format compatible with PFM characteristics as indicated in Table XXVIII.
2. With the emphasis enabled the above setup results in PFM frequencies of 53.27 MHz for the white level (100 Institute of Radio Engineers (IRE)/714 mV), 48.57 MHz for the blanking level (0 IRE/0 mv), and 46.67 MHz for sync tip (-40 IRE/-286 mV).

Table XXVIII. NSTS fiber optic video signal characteristics.

PFM Signal Bandwidth	40–72 Megahertz (MHz)
PFM Signal Characteristics	Square wave, FM signal characterized by nominal 50 percent duty cycle
PFM Center Frequency (Blanking Level)	48.57 MHz (0 IRE/0mV)
White Level Frequency	70.25 Mhz (100 IRE/714 mV)
Sync Tip Frequency	40.07 Mhz (–40 IRE/–286 mV)
Blanking Level Variation	+/– 2 Mhz
Video Signal Format	NTSC composite NTSC/EIA–RSA–170A (1)
Pre-emphasis/De-emphasis	per CCIR Recommendation 405 of EIA/TIA–250–C. (1) (2)
Bus Media	Fiber Optics on both SSMB and APM sides
Video Sync	EIA–RS–170A Compliant Black Burst Sync

Notes:

(1) Or any video/data format compatible with PFM characteristics as indicated in this Table.

(2) With the emphasis enabled the above set-up results in PFM frequencies of 53.27 MHz for the white level (100 IRE/714 mV), 48.57 MHz for the blanking level (0 IRE/0mv), and 46.67 MHz for sync tip (–40 IRE/–286 mV).

3.4.1.1.9.3 CIR NTSC PFM video transmitted optical power.

The CIR shall be designed to transmit a video PFM signal at an average optical power greater than -15.5 dBm.

3.4.1.1.9.4 Fiber optic cable characteristics.

The video/data and sync signals shall use fiber optic cable in accordance with Table XXIX.

3.4.1.1.9.5 PFM NSTC video fiber optic cable bend radius.

The CIR shall develop the routing, installation, and handling procedures to assure the minimum bend radius of 2 in. or greater is maintained at all times for the fiber optic cable.

Table XXIX. PFM NTSC video optical fiber characteristics.

Parameter	Dim.	Medium Characteristics
Operating Wave length (min/max)	nm	1270/1380
Fibre Type	–	graded index, multimode
Fibre Core Diameter (min/max)	μm	98/102
Fibre Cladding Diameter (min/max)	μm	138/142
Numerical Aperture (min/max)	–	0.28/0.32
Attenuation @ 1290± 10nm	dB/Km	≤ 4
Modal Bandwidth @ 1290± 10nm	MHz × Km	200
–Signal Timing:		
Optical Rise Time (10% to 90%)	ns	≤ 3.5
Optical Fall Time (10% to 90%)	ns	≤ 3.5
Random Jitter (peak to peak) (1)	ns	≤ 0.76
Data Dependent Jitter (peak to peak) (1)	ns	≤ 0.6
Duty Cycle Distortion (peak to peak) (1)	ns	≤ 1

Note:
(1) These parameter refer to fibre optic data test setup.

3.4.2 Flexibility and expansion.

a. The CIR software shall be modifiable via the ISS communication network.
b. CIR software shall be modularized separate from PI-specific hardware.
c. CIR software shall be written in C++ and/or Java programming languages with the exception of COTS software and software classified as time critical.
d. After deployment of the SAR, the CIR shall have the capability to transfer internal bus controller (Master) functions from the primary processor to at least one other processor.
e. Prior to SAR deployment, each computer communication bus (1553, Ethernet, etc.) shall be designed such that the transfer of all data from the basis experiments, as specified in FCF-DOC-002, and all associated CIR health data does not exceed 55% of bus bandwidth over any 10 s period.
f. After SAR deployment, each computer communication bus (1553, Ethernet, etc.) shall be designed such that all the transfer rates of all data from the basis experiments, as specified in FCF-DOC-002, and all associated CIR health data does not exceed 60% of the bus bandwidth over any 10 s period.
g. Prior to the deployment of the SAR, during all planned operational modes, all single board computers and associated circuit boards in the FIR and the CIR shall be designed to have their volatile memory (e.g., RAM) sized such that the basic software functions required to perform the basis experiments and collect generated data as specified in FCF-DOC-002 do not utilize more than 55 % of the bytes available for the particular volatile memory.
h. After SAR deployment, during all planned operational modes, all single board computers and associated circuit boards in the CIR shall be designed to have their volatile memory (e.g., RAM) sized such that the basic software functions required to perform the basis experiments and collect all generated data as specified in FCF-DOC-002 do not utilize more than 65 % of the bytes available for the particular volatile memory.

i. Prior to the deployment of the SAR, during all planned operational modes, all single board computers and associated circuit boards in the FIR and the CIR shall be designed to have their non-volatile memory sized such that the basic software functions required to perform the basis experiments and collect generated data as specified in FCF-DOC-002 do not utilize more than 50 % of the bytes available for the particular non-volatile memory.
j. After SAR deployment, during all planned operational modes, all single board computers and associated circuit boards in the CIR shall be designed to have their non-volatile memory sized such that the basic software functions required to perform the basis experiments and collect all generated data as specified in FCF-DOC-002 do not utilize no more than 80 % of the bytes available for the particular non-volatile memory.
k. Prior to the deployment of the SAR, during all planned operational modes, all mass storage in the FIR and the CIR shall be sized such that the space required to store all data does not exceed 50 % of the bytes available and 70 % of the data read/write rates available as specified in the basis experiments in FCF-DOC-002 for the particular mass storage. To meet this requirement it shall be assumed that no data can be offloaded from the mass storage during the conduct of the experiment (i.e., all information generated and sent to the mass storage must be retained).
l. After SAR deployment, during all planned operational modes, all mass storage in the CIR shall be sized such that the space required to store all data does not exceed 80 % of the bytes available or 70 % of the data read/write rates available as specified in the basis experiments in FCF-DOC-002 for the particular mass storage. To meet this requirement it shall be assumed that no data can be offloaded from the mass storage during the conduct of the experiment (i.e., all information generated and sent to the mass storage must be retained).

3.4.3 Software portability.

a. The CIR software shall be designed to facilitate migration for programs from systems supporting CIR development.
b. CIR software shall be designed to facilitate migration of programs to upgraded hardware and firmware.

3.4.4 Data date/time stamps.

a. All data shall be date/time stamped as specified in paragraph 3.2.1.35 by the primary computer collecting the data.
b. Data flowing from one computer to another where date/time stamps have been applied shall not have their date/time stamps overwritten.

3.5 Logistics.

3.5.1 Maintenance.

The CIR shall be designed to allow for changeout, maintenance, and upgrade of hardware and software to conduct the basis experiments as specified in FCF-DOC-002.

3.5.2 Supply.

The CIR shall be designed to perform a minimum of 5 basis-type experiments per year as specified in FCF-DOC-002 using no more than the up-mass and stowage volume resupply requirements as specified in paragraph 3.2.2.

3.5.3 Facilities and facility equipment.

Facilities and facility equipment are described in FCF-SPC-0005.

3.6 Personnel and training.

3.6.1 Personnel.

a. The CIR shall be designed to be nominally maintained and operated by one crew member.
b. The CIR shall be designed to be operated using ground commands once experiment setup is completed by the crew.
c. The CIR shall be designed such that no more than two crew members are required for off-nominal and troubleshooting operations.

3.6.2 Training.

The CIR shall be designed for simple and logical installation, maintenance, and operation to minimize crew training. Details concerning training are provided in FCF-DOC-0005.

3.7 Major component characteristics.

The major component characteristics (including specific performance requirements) of the CIR assemblies listed in paragraphs 3.1.6 and 3.1.9 are given in their respective individual product specifications.

3.8 Precedence.

All specifications, standards, exhibits, drawings, or other documents that are referenced in this specification are hereby incorporated as cited, with the exception of those documents specifically cited to be used for reference only.

4.0 QUALITY ASSURANCE

Verification of the CIR shall be performed as specified in this section. Verifications shall show compliance with each "shall" statement in sections 3.0 and 5.0. Non "shall" statements are not required to be verified for compliance.

4.1 General.

The primary location for CIR verification will be at the contractor test facility or at locations contracted to perform verifications by the contractor. Data and reports generated as part of the verification process will be retained for the life of the CIR. The CIR verification will be conducted though inspection, analysis, demonstration, and test.

The following verification methods are defined and shall be used to qualify the system:

1. Inspection - Verification by visual examination of the item, or reviewing descriptive documentation, and comparing the appropriate characteristics with predetermined standards to determine conformance to requirements without the use of special laboratory equipment or procedures.
2. Analysis - Verification by technical or mathematical models or simulation, algorithms, charts, graphs, or circuit diagrams, and representative data.
3. Demonstration - Verification by operation, adjustment or reconfiguration of items performing their designed functions under specific scenarios. The items may be instrumented and quantitative limits or performance monitored, but only check sheets rather than actual performance data are required to be recorded.
4. Test - Verification though systematic exercising of the item under all appropriated conditions. Performance is quantitatively measured either during or after the controlled application of either real or simulated functional or environmental stimuli. The analysis of data derived from a test is an integral part of the test and may involve automated data reduction to produce the necessary results.

The verification program is an incremental process that is a companion to the assembly process. Component level requirements are verified first, followed by assembly level verification, to the system level verification. Requirements in this specification may have been verified at lower levels. Inspection of data from lower level component and assembly verifications will be used to verify appropriate requirements in this specification.

4.1.1 Responsibility for verifications.

Unless otherwise specified in the contract, the contractor is responsible for the performance of all verification requirements as specified herein. Except as otherwise specified in the contract, the contractor may use any facility suitable for the performance of the verification requirements specified herein, unless disapproved by the government. The government reserves the right to perform any of the verifications set forth in this specification.

4.1.2 Special tests and examinations.

All test measurement equipment and standards used in performance of the verifications specified herein shall have their calibration data traceable to NIST measurement standards.

4.2 Verification requirements.

All verification tests shall be performed using the preproduction sample as specified in CIR-SPC-0013. The sample shall be modified to the extent necessary to conduct testing. All CIR hardware/software deviating from the preproduction sample shall be documented. Written approval from the government quality assurance representative or the government quality assurance designee to proceed with the verification test using CIR hardware/software that deviates from the preproduction sample shall be obtained before beginning the verification test. Detailed verification for the CIR are specified in CIR-PLN-0056.

4.2.1 Performance characteristics.

Verification that the CIR meets the performance characteristics requirements as specified herein from the requirements in FCF-DOC-002, with the interfaces necessary to accommodate PI hardware, software and resources, and FCF-SPC-0001, shall be by inspection. Verification shall be considered successful when the inspection shows that the verifications as specified herein meet the performance characteristics requirements as specified herein from the requirements in FCF-DOC-002, with the interfaces necessary to accommodate PI hardware, software and resources, and FCF-SPC-0001.

4.2.1.1 Minimum utilization.

The CIR design capability, interfacing with applicable PI hardware and resources, to support a minimum utilization of five combustion basis experiments as specified in FCF-DOC-002 shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR design is capable of supporting a minimum utilization of five combustion basis experiments as specified in FCF-DOC-002.

4.2.1.2 Additional utilization.

The CIR capability, interfacing with applicable hardware and resources, to accommodate a minimum of five additional combustion experiments from commercial and/or international sources from the reference information obtained from GRC shall be verified by analysis. The basis experiments used in paragraph 4.2.1.1 shall be used to perform this analysis. Verification shall be considered successful when the analysis shows the CIR is capable of accommodating a minimum of additional five combustion experiments from commercial and/or international sources from the reference information obtained from GRC.

4.2.1.3 Basis experiment capacity.

The CIR capability to meet a minimum of 80% of the combustion basis experiments' test matrices using the combustion basis experiments as specified in FCF-DOC-002 shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR meets a minimum of 80% of the combustion basis experiments' test matrices using the combustion basis experiments as specified in FCF-DOC-002.

4.2.1.4 Combustion chamber science volume.

The CIR combustion chamber science volume having a minimum volume of 100 liters shall be verified by inspection and analysis of the combustion chamber internal volume. Verification shall be considered successful when the inspection and analysis show the CIR combustion chamber science volume has a minimum volume of 100 liters.

4.2.1.5 Combustion chamber science width.

The CIR combustion chamber internal minimum dimensions of 45 cm length and 20 cm diameter shall be verified by inspection of the combustion chamber internal width. Verification shall be considered successful when the inspection shows the CIR combustion chamber internal minimum dimensions are no less than 45 cm in length and 20 cm in diameter.

4.2.1.6 Combustion chamber internal cleanliness.

4.2.1.6.1 Initial combustion chamber internal cleanliness.

The initial CIR combustion chamber internal cleanliness to maintain a Visibly Clean - Sensitive (VC - S) level from the time of shipment to the launch facility until the CIR is set up for its first experiment shall be verified by inspection at an observed distance from 2 to 4 feet with an incident light level of at least 50 foot-candles. Verification shall be considered successful when the inspection shows the CIR combustion chamber internal cleanliness maintains a VC - S level from the time of shipment to the launch facility until the CIR is set up for its first experiment.

4.2.1.6.2 Combustion chamber cleanliness on orbit.

The CIR combustion chamber internal cleanliness on orbit to maintain the optical science requirements shall be verified by tests using images taken during experiment set up and comparing those images to standard acceptance images for that experiment. Verification shall be considered successful when the tests show the CIR combustion chamber internal cleanliness on orbit maintains the optical science requirements.

4.2.1.7 Fuel/oxidizer storage.

a. The CIR capability to provide gaseous fuel, oxidizer, and diluent storage shall be verified by analysis of the CIR design. Verification shall be considered successful when the analysis shows the CIR provides gaseous fuel, oxidizer, and diluent storage.

b. The CIR capability to provide PI interfaces to accommodate storage of gaseous, liquid, and solid fuels, oxidizers, and diluents as specified in paragraph 3.2.1.7b shall be verified by analysis of the CIR design. Verification shall be considered successful when the analysis shows the CIR capability to provide PI interfaces to accommodate storage of gaseous, liquid, and solid fuels, oxidizers, and diluents as specified in paragraph 3.2.1.7b.

4.2.1.8 Gas distribution.

a. The CIR capability to deliver and control ISS nitrogen to the combustion chamber shall be verified by test. Verification shall be considered successful when the test shows the CIR can deliver and control ISS nitrogen to the combustion chamber.
b. The CIR capability to deliver and control PI-provided gases given in paragraph 3.2.1.7b to the combustion chamber shall be verified by test. Verification shall be considered successful when the test shows the CIR can deliver and control PI-provided gases given in paragraph 3.2.1.7b to the combustion chamber.

4.2.1.9 Gas mixing.

The CIR capability to mix gases inside the combustion chamber shall be verified by test. Verification shall be considered successful when the test shows the CIR can mix gases inside the combustion chamber.

4.2.1.10 Ignition interface.

a. The CIR capability to provide at least one interface capable of supplying 28 Vdc power and a control interface for igniting fuel/oxidizer mixtures to the PI-specific hardware shall be by test. Verification shall be considered successful when the test shows the CIR can provide the at least one interface capable of supplying 28 Vdc power and a control interface for igniting fuel/oxidizer mixtures to the PI-specific hardware.
b. The CIR capability to provide a combustion chamber port capable of supplying 120 Vdc power and a control interface for igniting fuel/oxidizer mixtures to the PI-specific hardware shall be by inspection. Verification shall be considered successful when the inspection shows the CIR can provide a combustion chamber port capable of supplying 120 Vdc power and a control interface for igniting fuel/oxidizer mixtures to the PI-specific hardware.

4.2.1.11 Science acceleration and vibration.

The CIR capability to maintain an acceleration and vibration environment at the combustion chamber wall as shown in Figure 7 during the operation of the experiment test points shall be verified by analysis using the third octave band. Verification shall be considered successful when the analysis shows the CIR can maintain an acceleration and vibration environment at the combustion chamber wall as shown in Figure 7 during the operation of the experiment test points.

4.2.1.12 Combustion chamber pressure.

The CIR capability to provide pressure control from 0.02 to 3 atm (± 5% for any measurement within the range) shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide pressure control from 0.02 to 3 atm (± 5% for any measurement within the range).

4.2.1.13 Containment pressure.

The CIR capability to contain a minimum pressure of 9 atm shall be verified by analysis and test. Verification shall be considered successful when the structural analysis shows the CIR can contain a minimum pressure of 9 atm and the pressure testing of the CIR shows a leakage rate of less than 1.91 psia/h.

4.2.1.14 Initial gas temperatures.

a. The CIR capability to deliver initial gas temperatures from 278 to 318 K to the combustion chamber shall be by analysis. Verification shall be considered successful when the analysis shows the CIR can deliver initial gas temperatures from 278 to 318 K to the combustion chamber.
b. The CIR design to provide 28 VDC electrical power, data and control interfaces and cooling water interfaces as specified in paragraph 3.3.3.6.1 to allow PI control of gas temperatures from 268 to 320 K shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR design to provide 28 VDC electrical power, data and control interfaces and cooling water interfaces as specified in paragraph 3.3.3.6.1 to allow PI control of gas temperatures from 268 to 320 K.

4.2.1.15 Condensed phase fuel temperatures.

The CIR design to provide 28 VDC electrical power, data and control interfaces and cooling water interfaces as specified in paragraph 3.3.3.6.1 to allow PI control of condensed phase fuel temperatures from 268 to 320 K shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR design to provide 28 VDC electrical power, data and control interfaces and cooling water interfaces as specified in paragraph 3.3.3.6.1 to allow PI control of condensed phase fuel temperatures from 268 to 320 K.

4.2.1.16 Science oxygen compatibility.

The CIR internal gas supply system, gas chromatograph, combustion chamber, and exhaust vent package hardware compatibility with oxygen at a concentration no less than 70% shall be verified by analysis and inspection of materials. The analysis verification shall be considered successful when the analysis of the wetted materials of the internal gas supply system, gas chromatograph, combustion chamber, and exhaust vent package hardware shows them to be compatible with oxygen at a concentration no less than 70%. The inspection verification shall be considered successful when the inspection materials certifications of the wetted materials of the internal gas supply system, gas chromatograph, combustion chamber, and exhaust vent package hardware show them to be compatible with oxygen at a concentration no less than 70%.

4.2.1.17 Gas blending.

a. The CIR capability to provide partial pressure gas blending capability of oxidizer with diluents from 0 to 70% (± 2% absolute) oxidizer concentration shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide partial pressure gas blending capability of oxidizer with diluents from 0 to 70% (± 2% absolute) oxidizer concentration.
b. The CIR capability to provide dynamic gas blending capability of oxidizer with diluents from 0 to 25% (± 1% absolute) oxidizer concentration shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide dynamic gas blending capability of oxidizer with diluents from 0 to 25% (± 1% absolute) oxidizer concentration.
c. The CIR capability to provide dynamic gas blending capability of oxidizer with diluents from 0 to 70% (± 2% of reading) oxidizer concentration shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide dynamic gas blending capability of oxidizer with diluents from 0 to 70% (± 2% of reading) oxidizer concentration.

4.2.1.18 Premixed gases.

The CIR capability to dispense premixed gases from gas bottles within the safety constraints specified by the FCF Project and in paragraph 3.3.6.30 shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can dispense premixed gases from gas within the safety constraints specified by the FCF Project and in paragraph 3.3.6.30.

4.2.1.19 Gaseous fuel flow.

The CIR capability to control gaseous fuel flow from 0 to 30 scc/s (± 5% for any measurement within the range) shall be verified by test. The verification shall be considered successful when the test shows the CIR can control gaseous fuel flow from 0 to 30 scc/s (± 5% for any measurement within the range).

4.2.1.20 Gaseous oxidizer/diluent flow.

a. The CIR capability control gaseous oxidizer/diluent flow to the combustion chamber in a range from 0 to 1,500 scc/s ± 5% of the set point shall be verified by test. The verification shall be considered successful when the test shows the CIR capability control gaseous oxidizer/diluent flow to the combustion chamber in a range from 0 to 1,500 scc/s ± 5% of the set point.
b. The CIR providing interfaces to allow the use of PI hardware to control the oxidizer/diluent flow within the combustion chamber in a range from 0 to 4,000 scc/s shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR providing interfaces to allow the use of PI hardware to control the oxidizer/diluent flow within the combustion chamber in a range from 0 to 4,000 scc/s.

c. The CIR shall allow a maximum oxidizer/diluent flow of 1,500 scc/s from the combustion chamber provided the gas meets the constraints specified in paragraph 3.2.2.9.4.2 shall be verified by test. The verification shall be considered successful when the test shows the CIR shall allow a maximum oxidizer/diluent flow of 1,500 scc/s from the combustion chamber provided the gas meets the constraints specified in paragraph 3.2.2.9.4.2.
d. The CIR shall allow a maximum oxidizer/diluent flow of 300 scc/s from the combustion chamber through an adsorber cartridge in order to meet meets the constraints specified in paragraph 3.2.2.9.4.2 shall be verified by test. The verification shall be considered successful when the test shows the CIR shall allow a maximum oxidizer/diluent flow of 300 scc/s from the combustion chamber through an adsorber cartridge in order to meet meets the constraints specified in paragraph 3.2.2.9.4.2.

4.2.1.21 Constant oxidizer concentration within the combustion chamber.

The CIR capability to maintain constant oxidizer concentration within the combustion chamber to 1% of the desired set point during combustion events when the oxidizer replenishment rate is less than 0.3 <TBD 04-01> grams/s and the total oxidizer replenishment does not exceed 600 grams shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to maintain constant oxidizer concentration within the combustion chamber to 1% of the desired set point during combustion events when the oxidizer replenishment rate is less than 0.3 <TBD 04-01> grams/s and the total oxidizer replenishment does not exceed 600 grams.

4.2.1.22 Number and duration of test points.

The CIR capability of providing the following capacities to support the number and duration of test points in accordance with the combustion basis experiments as specified in FCF-DOC-002:

1. 60 Gbytes image processing storage
2. 120 Gbytes portable data storage
3. 2.25 liter fuel storage
4. 3.80 liter oxidizer storage
5. 3.80 liter diluent storage

shall be verified by analysis. The verification shall be considered successful when the analysis shows the capacities, along with the operational scenarios, support the number and duration of test points in accordance with the combustion basis experiments as specified in FCF-DOC-002.

4.2.1.23 Imaging and image measurement.

a. The CIR imaging and image measurement capability to permit positioning for orthogonal and near-orthogonal views with respect to other imaging hardware shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR imaging and image measurement capability to permit positioning for orthogonal and near-orthogonal views with respect to other imaging hardware.
b. The CIR imaging and image measurement capability mating with dimensionally controlled positional interfaces on the mounting surface and align with the combustion chamber windows shall be verified by inspection. The verification shall be considered successful

when the inspection shows the CIR imaging and image measurement capability mating with dimensionally controlled positional interfaces on the mounting surface and align with the combustion chamber windows.

c. The CIR imaging and image measurement capability to operate from CIR common interfaces for power and control shall be verified by test. The verification shall be considered successful when the inspection shows the CIR imaging and image measurement capability to operate from CIR common interfaces for power and control.
d. The CIR imaging and image measurement capability to use common interfaces with CIR image and data acquisition systems shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR imaging and image measurement capability to use common interfaces with CIR image and data acquisition systems.
e. The CIR imaging and image measurement capability to use digital output imagers shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR imaging and image measurement capability to use digital output imagers.
f. The CIR imaging and image measurement capability to provide common interfaces that permit on-orbit hardware reconfiguration within an assembly for changes in selected performance ranges shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR imaging and image measurement capability to provide common interfaces that permit on-orbit hardware reconfiguration within an assembly for changes in selected performance ranges.
g. The CIR capability to provide an analog imaging interface through the combustion chamber shall be verified by inspection. The inspection shall be considered successful when the inspection shows the CIR capability to provide an analog imaging interface through the combustion chamber.

4.2.1.23.1 Color imaging.

a. The CIR color imaging capability of providing a spectral range of 400-700 nm shall be verified by test. The verification shall be considered successful when the test shows the CIR color imaging capability of providing a spectral range of 400-700.
b. The CIR color imaging capability of having a square field of view from 90 to 180 mm with a corresponding maximum resolution range of 2.5 to 1 line pairs/mm shall be verified by test. The verification shall be considered successful when the test shows the CIR color imaging capability of having a square field of view from 90 to 180 mm with a corresponding maximum resolution range of 2.5 to 1 line pairs/mm.
c. The CIR color imaging capability of having a field of view from 175 mm square to 350 mm diameter (962 cm^2) with a corresponding maximum resolution range of 1 to 0.5 line pairs/mm shall be verified by test. The verification shall be considered successful when the test shows the CIR color imaging capability of having a field of view from 175 mm square to 350 mm diameter (962 cm^2) with a corresponding maximum resolution range of 1 to 0.5 line pairs/mm.
d. The CIR color imaging capability of providing an interface that permits attachment of PI provided hardware to provide a 1000 cm^2 field of view and a 350 mm square field of view shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR color imaging capability of providing an interface that permits attachment of hardware to provide a 1000 cm^2 field of view and a 350 mm square field of view.

e. The CIR color imaging capability of a motorized focus shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR color imaging capability of a motorized focus.
f. The CIR color imaging capability of a motorized aperture for exposure control shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR imaging capability of a motorized aperture for exposure control.
g. The CIR color imaging capability a frame rate range from 0.1 to at least 30 frames/second shall be verified by shall be verified by test. The verification shall be considered successful when the test shows the CIR color imaging capability a frame rate range from 0.1 to at least 30 frames/second.
h. The CIR color imaging capability of a run time of at least 18 minutes at 30 fps shall be verified by test. The verification shall be considered successful when the test shows the CIR color imaging capability of a run time of at least 18 minutes at 30 fps.

4.2.1.23.2 Visible spectrum high frame rate black and white imaging.

a. The CIR visible spectrum high frame rate black and white imaging capability to provide a spectral range of from 400 to 1000 nm at 5% transmission response shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to provide a spectral range of from400 to 1000 nm at 5% transmission response.
b. The CIR visible spectrum high frame rate black and white imaging capability to have an instantaneous field of view 9 mm square steerable over a 35 mm square total field that is truncated at the corners by a 46 mm diameter circle shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to have an instantaneous field of view 9 mm square steerable over a 35 mm square total field that is truncated at the corners by a 46 mm diameter circle.
c. The CIR visible spectrum high frame rate black and white imaging capability to have a total field area of 12 cm^2 shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to have a total field area of 12 cm^2.
d. The CIR visible spectrum high frame rate black and white imaging capability to provide interfaces that permit attachment of PI provided hardware to provide a 16 cm^2 field of view and a 35 cm square field of view shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR visible spectrum high frame rate black and white imaging capability to provide interfaces that permit attachment of PI provided hardware to provide a 16 cm^2 field of view and a 35 cm square field.
e. The CIR visible spectrum high frame rate black and white imaging capability to have a resolution of 27.8 line pairs/mm at Nyquist limit binned shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to have a resolution of 27.8 line pairs/mm at Nyquist limit binned.

f. The CIR visible spectrum high frame rate black and white imaging capability to use motorized steering of the instantaneous field of view for automatic tracking at 10 mm/s shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to use motorized steering of the instantaneous field of view for automatic tracking at 10 mm/s.
g. The CIR visible spectrum high frame rate black and white imaging capability to use motorized focus over a 30 mm depth range in object space shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to use motorized focus over a 30 mm depth range in object space.
h. The CIR visible spectrum high frame rate black and white imaging capability to provide an interface that permits attachment of PI provided hardware to provide a 40 mm focus range shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR visible spectrum high frame rate black and white imaging capability to provide an interface that permits attachment of PI provided hardware to provide a 40 mm focus range.
i. The CIR visible spectrum high frame rate black and white imaging capability to provide a telecentric optical system to account for droplet drift perpendicular to the imaging plane shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to provide a telecentric optical system to account for droplet drift perpendicular to the imaging plane.
j. The CIR visible spectrum high frame rate black and white imaging capability to provide an interface for a PI provided liquid crystal tunable filter shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to provide an interface for a PI provided liquid crystal tunable filter.
k. The CIR visible spectrum high frame rate black and white imaging capability to have a frame rate range from 1 to 100 frames/second binned; to 30 frames/second not binned shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to have a frame rate range from 1 to 100 frames/second binned; to 30 frames/second not binned.
l. The CIR visible spectrum high frame rate black and white imaging capability to have a programmable control of frame rate including closed loop sensing with event trigger shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to have a programmable control of frame rate including closed loop sensing with event trigger.
m. The CIR visible spectrum high frame rate black and white imaging capability to have a run time of 15 minutes at 30 and at 100 fps shall be verified by test. The verification shall be considered successful when the test shows the CIR visible spectrum high frame rate black and white imaging capability to have a run time of 15 minutes at 30 and at 100 fps.

4.2.1.23.3 High bit depth multispectral black and white imaging.

a. The high bit depth multispectral black and white imaging capability having a spectral range from 650 to1000 nm tunable with a liquid crystal tunable filter shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability having a spectral range from 650 to1000 nm tunable with a liquid crystal tunable filter.
b. The high bit depth multispectral black and white imaging capability providing spectral range of 400 to 1000 at 5% transmission response with no liquid crystal tunable filter shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability providing spectral range of 400 to 1000 at 5% transmission response with no liquid crystal tunable filter.
c. The high bit depth multispectral black and white imaging capability having a field of view 80 mm diameter with a corresponding maximum resolution of 5 line pairs/mm with a liquid crystal tunable filter shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability having a field of view 80 mm diameter with a corresponding maximum resolution of 5 line pairs/mm with a liquid crystal tunable filter.
d. The high bit depth multispectral black and white imaging capability having a field of view 50 mm square with a corresponding maximum resolution of 10 line pairs/mm without a liquid crystal tunable filter shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability having a field of view 50 mm square with a corresponding maximum resolution of 10 line pairs/mm without a liquid crystal tunable filter.
e. The high bit depth multispectral black and white imaging capability providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 50 to 200 cm^2 field of view or a 3.3 to 5 cm square field of view or a 5.6 to 16 cm square field of view shall be verified by inspection. The verification shall be considered successful when the inspection shows the high bit depth multispectral black and white imaging capability providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 50 to 200 cm^2 field of view or a 3.3 to 5 cm square field of view or a 5.6 to 16 cm square field of view.
f. The high bit depth multispectral black and white imaging capability providing interfaces that permit attachment of PI imager hardware to provide 0.018 mm resolution at FOVs from 18 to 35 mm at greater than 15 fps shall be verified by inspection. The verification shall be considered successful when the inspection shows the high bit depth multispectral black and white imaging capability providing interfaces that permit attachment of PI imager hardware to provide 0.018 mm resolution at FOVs from 18 to 35 mm at greater than 15 fps.
g. The high bit depth multispectral black and white imaging capability having a depth of field maximum of 110 mm at a resolution of 1 line pair/mm maximum with an 80 mm field of view shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability having a depth of field maximum of 110 mm at a resolution of 1 line pair/mm maximum with an 80 mm field of view.

h. The high bit depth multispectral black and white imaging capability having a depth of field minimum of 20 mm at a resolution of 10 line pairs/mm with a 50 mm field of view shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability having a depth of field minimum of 20 mm at a resolution of 10 line pairs/mm with a 50 mm field of view.
i. The high bit depth multispectral black and white imaging capability having a manual aperture adjustment for exposure or depth of field control shall be verified by inspection. The verification shall be considered successful when the inspection shows the high bit depth multispectral black and white imaging capability having a manual aperture adjustment for exposure or depth of field control.
j. The high bit depth multispectral black and white imaging capability having a framing rate of 15 frames/second (without spectral tuning) shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability having a framing rate of 15 frames/second (without spectral tuning).
k. The high bit depth multispectral black and white imaging capability having a bit depth of 12 shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability having a bit depth of 12.
l. The high bit depth multispectral black and white imaging capability having a run time of at least 20 minutes at 15 fps shall be verified by test. The verification shall be considered successful when the test shows the high bit depth multispectral black and white imaging capability having a run time of at least 20 minutes at 15 fps.

4.2.1.23.4 Ultraviolet (UV) imaging.

a. The near UV imaging capability having a spectral range of 250 to 700 nm shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a spectral range of 250 to 700 nm.
b. The near UV imaging capability shall provide an interface for manual insertion of spectral filters shall be verified by inspection. The verification shall be considered successful when the inspection shows.
c. The near UV imaging capability having a spectral filter with a 310 nm peak with 10 nm width at half maximum transmission shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a spectral filter with a 310 nm peak with 10 nm width at half maximum transmission.
d. The near UV imaging capability having a field of view 100 mm square with a corresponding maximum resolution of 1.8 line pairs/mm binned and 2.8 line pairs/mm not binned shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a field of view 100 mm square with a corresponding maximum resolution of 1.8 line pairs/mm binned and 2.8 line pairs/mm not binned.
e. The near UV imaging capability having a field of view 42 mm square with a corresponding maximum resolution of 4.3 line pairs/mm binned and 6.7 line pairs/mm not binned shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a field of view 42 mm square with

a corresponding maximum resolution of 4.3 line pairs/mm binned and 6.7 line pairs/mm not binned.

f. The near UV imaging capability providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 100 to 1000 cm^2 field of view or a 10 to 35 cm square field of view or a 1.9 to 4.2 cm square field of view shall be verified by inspection. The verification shall be considered successful when the inspection shows the near UV imaging capability providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 100 to 1000 cm^2 field of view or a 10 to 35 cm square field of view or a 1.9 to 4.2 cm square field of view.
g. The near UV imaging capability providing interfaces that permit attachment of PI imager hardware to provide 0.5 mm resolution at field of views from 20 to 35 cm at 60 fps and 0.2 to 0.5 mm resolution at field of views from 10 to 20 cm at 30 fps and 0.05 to 0.18 mm resolution at field of views from 1.9 to 4.5 cm at up to 100 fps shall be verified by inspection. The verification shall be considered successful when the inspection shows the near UV imaging capability providing interfaces that permit attachment of PI imager hardware to provide 0.5 mm resolution at field of views from 20 to 35 cm at 60 fps and 0.2 to 0.5 mm resolution at field of views from 10 to 20 cm at 30 fps and 0.05 to 0.18 mm resolution at field of views from 1.9 to 4.5 cm at up to 100 fps.
h. The near UV imaging capability having a depth of field maximum of 51mm at a resolution of 1 line pair/mm maximum with a 100 mm field of view shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a depth of field maximum of 51mm at a resolution of 1 line pair/mm maximum with a 100 mm field of view.
i. The near UV imaging capability having a depth of field minimum of 5 mm at a resolution of 6.7 line pairs/mm with a 42 mm field of view shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a depth of field minimum of 5 mm at a resolution of 6.7 line pairs/mm with a 42 mm field of view.
j. The near UV imaging capability having a manual aperture adjustment for exposure or depth of field control shall be verified by inspection. The verification shall be considered successful when the inspection shows the near UV imaging capability having a manual aperture adjustment for exposure or depth of field control.
k. The near UV imaging capability having manual focus adjustment shall be verified by inspection. The verification shall be considered successful when the inspection shows the near UV imaging capability having manual focus adjustment.
l. The near UV imaging capability having a maximum binned framing rate of 60 frames/s shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a maximum binned framing rate of 60 frames/s.
m. The near UV imaging capability having a maximum full resolution framing rate of 30 frames/s shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a maximum full resolution framing rate of 30 frames/s.
n. The near UV imaging capability providing interfaces that permit attachment of PI imager hardware to provide frame rates from 60 to 100 fps shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging

capability providing interfaces that permit attachment of PI imager hardware to provide frame rates from 60 to 100 fps.

o. The near UV imaging capability having a bit depth of 8 shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a bit depth of 8.
p. The near UV imaging capability having a run time of 40 minutes at 60 fps (binned) shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a run time of 40 minutes at 60 fps (binned).
q. The near UV imaging capability having a run time of 20 minutes at 30 fps (full resolution) shall be verified by test. The verification shall be considered successful when the test shows the near UV imaging capability having a run time of 20 minutes at 30 fps (full resolution).

4.2.1.23.5 Near infrared (IR) imaging.

a. The near IR imaging capability having a spectral range from 400 to 900 nm shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a spectral range from 400 to 900 nm.
b. The near IR imaging capability of having an interface for manual insertion of spectral filters shall be verified by inspection. The verification shall be considered successful when the inspection shows the near IR imaging capability of having an interface for manual insertion of spectral filters.
c. The near IR imaging capability having a square field of view from 45 to 90 mm with a corresponding maximum resolution range binned of 4.3 to 2.2 line pairs/mm shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a square field of view from 45 to 90 mm with a corresponding maximum resolution range binned of 4.3 to 2.2 line pairs/mm.
d. The near IR imaging capability having a square field of view from 90 to 180 mm with a corresponding maximum resolution range binned of 2.2 to 1.1 line pairs/mm shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a square field of view from 90 to 180 mm with a corresponding maximum resolution range binned of 2.2 to 1.1 line pairs/mm.
e. The near IR imaging capability of providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 324 to 700 cm^2 field of view or an 18 to 35 cm square field of view shall be verified by inspection. The verification shall be considered successful when the inspection shows the near IR imaging capability of providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 324 to 700 cm^2 field of view or an 18 to 35 cm square field of view.
f. The near IR imaging capability of providing interfaces that permit attachment of PI imager hardware to provide 0.5 mm resolution for field of views from 20 to 30 cm at 60 fps and 0.2 mm resolution for field of views from 8 to 35 cm at 60 fps shall be verified by inspection. The verification shall be considered successful when the inspection shows the near IR imaging capability of providing interfaces that permit attachment of PI imager hardware to provide 0.5 mm resolution for field of views from 20 to 30 cm at 60 fps and 0.2 mm resolution for field of views from 8 to 35 cm at 60 fps.
g. The near IR imaging capability having a depth of field maximum of 35 cm at a resolution of 1 line pair/mm maximum with a 45 mm field of view shall be verified by test. The

verification shall be considered successful when the test shows the near IR imaging capability having a depth of field maximum of 35 cm at a resolution of 1 line pair/mm maximum with a 45 mm field of view.

h. The near IR imaging capability having a depth of field minimum of 20 mm at a resolution of 2 line pairs/mm with a 180 mm field of view shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a depth of field minimum of 20 mm at a resolution of 2 line pairs/mm with a 180 mm field of view.
i. The near IR imaging capability having a motorized focus shall be verified by inspection. The verification shall be considered successful when the inspection shows the near IR imaging capability having a motorized focus.
j. The near IR imaging capability having a motorized aperture for exposure control shall be verified by inspection. The verification shall be considered successful when the inspection shows the near IR imaging capability having a motorized aperture for exposure control.
k. The near IR imaging capability having a maximum frame rate of 60 frames/second (binned) shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a maximum frame rate of 60 frames/second (binned).
l. The near IR imaging capability having a maximum frame rate of 30 frames/second (full resolution) shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a maximum frame rate of 30 frames/second (full resolution).
m. The near IR imaging capability having a bit depth of 8 shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a bit depth of 8.
n. The near IR imaging capability having a maximum run time of 40 minutes at 60 fps (binned) shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a maximum run time of 40 minutes at 60 fps (binned).
o. The near IR imaging capability having a maximum run time of 20 minutes at 30 fps (full resolution) shall be verified by test. The verification shall be considered successful when the test shows the near IR imaging capability having a maximum run time of 20 minutes at 30 fps (full resolution).

4.2.1.23.6 Mid IR imaging.

a. The mid IR imaging capability having a spectral range from 1000 to5000 nm shall be verified by test. The verification shall be considered successful when the test shows the mid IR imaging capability having a spectral range from 1000 to5000 nm.
b. The mid IR imaging capability having an interface for manual insertion of spectral filters shall be verified by inspection. The verification shall be considered successful when the inspection shows the mid IR imaging capability having an interface for manual insertion of spectral filters.
c. The mid IR imaging capability having an interface for mounting a filter wheel shall be verified by inspection. The verification shall be considered successful when the

inspection shows the mid IR imaging capability having an interface for mounting a filter wheel.

d. The mid IR imaging capability of providing interfaces for PI provided imagers and optics operating in the spectral range from 8000 to 14000 nm shall be verified by inspection. The verification shall be considered successful when the inspection shows the mid IR imaging capability of providing interfaces for PI provided imagers and optics operating in the spectral range from 8000 to 14000 nm.
e. The mid IR imaging capability having a field of view 180 x 135 mm with a corresponding maximum resolution of 0.9 line pairs/mm shall be verified by test. The verification shall be considered successful when the test shows the mid IR imaging capability having a field of view 180 x 135 mm with a corresponding maximum resolution of 0.9 line pairs/mm.
f. The mid IR imaging capability of providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 240 to 1000 cm^2 field of view or an 18 to 35 cm axial and/or a 13.5 to 35 cm lateral field of view shall be verified by inspection. The verification shall be considered successful when the inspection shows the mid IR imaging capability of providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 240 to 1000 cm^2 field of view or an 18 to 35 cm axial and/or a 13.5 to 35 cm lateral field of view.
g. The mid IR imaging capability of providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 0.2 to 0.3 mm resolution for field of views from 1.9 to 3.1 cm shall be verified by inspection. The verification shall be considered successful when the inspection shows the mid IR imaging capability of providing interfaces that permit attachment of PI objective and/or relay optics hardware to provide a 0.2 to 0.3 mm resolution for field of views from 1.9 to 3.1 cm.
h. The mid IR imaging capability providing interfaces that permit attachment of PI imager hardware to provide 0.08 to 0.5 mm resolution for field of views from 10 to 35 cm at 60 fps shall be verified by inspection. The verification shall be considered successful when the inspection shows the mid IR imaging capability providing interfaces that permit attachment of PI imager hardware to provide 0.08 to 0.5 mm resolution for field of views from 10 to 35 cm at 60 fps.
i. The mid IR imaging capability having a depth of field maximum of 350 mm at a resolution of 0.25 line pairs/mm maximum with a 183 mm axial field of view shall be verified by test. The verification shall be considered successful when the test shows the mid IR imaging capability having a depth of field maximum of 350 mm at a resolution of 0.25 line pairs/mm maximum with a 183 mm axial field of view.
j. The mid IR imaging capability having a depth of field minimum of 5 mm at a resolution of 0.9 line pairs/mm with a 183 mm field of view shall be verified by test. The verification shall be considered successful when the test shows the mid IR imaging capability having a depth of field minimum of 5 mm at a resolution of 0.9 line pairs/mm with a 183 mm field of view.
k. The mid IR imaging capability having a maximum frame rate of 60 frames/second shall be verified by test. The verification shall be considered successful when the test shows the mid IR imaging capability having a maximum frame rate of 60 frames/second.

l. The mid IR imaging capability having a bit depth of 12 shall be verified by test. The verification shall be considered successful when the test shows the mid IR imaging capability having a bit depth of 12.
m. The mid IR imaging capability having a run time of 200 minutes at 60 fps shall be verified by test. The verification shall be considered successful when the test shows the mid IR imaging capability having a run time of 200 minutes at 60 fps.

4.2.1.23.7 Image illumination.

a. The image illumination capability having a field of view 80 mm diameter shall be verified by test. Verification shall be considered successful when the test shows the image illumination capability having a field of view 80 mm diameter.
b. The image illumination capability having a spectral range from 650 to 1000 nm shall be verified by test. Verification shall be considered successful when the test shows the image illumination capability having a spectral range from 650 to 1000 nm.
c. The image illumination capability being collimated shall be verified by test. Verification shall be considered successful when the test shows the image illumination capability being collimated.
d. The image illumination capability including laser diode source shall be verified by inspection. Verification shall be considered successful when the inspection shows the image illumination capability including laser diode source.

4.2.1.24 Gas phase temperature point measurements.

The CIR capability of providing gas phase temperature point measurement interfaces in 12 separate locations to support PI provided gas phase temperature measurements shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR capability of providing gas phase temperature point measurement interfaces in 12 separate locations to support PI provided gas phase temperature measurements.

4.2.1.25 Condensed phase temperature point measurements.

The CIR capability to provide condensed phase temperature point measurement interfaces in 20 separate locations to support PI provided gas phase temperature measurements shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR to provide condensed phase temperature point measurement interfaces in 20 separate locations to support PI provided gas phase temperature measurements.

4.2.1.26 Gas phase temperature field measurements.

a. The CIR capability to provide a gas phase temperature field measurement range from 280 to 1,773 K with a temperature measurement resolution range from 10 to 100 K shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide a gas phase temperature field measurement range from 280 to 1,773 K with a temperature measurement resolution range from 10 to 100 K.
b. The CIR providing interfaces for PI-provided gas phase field measurements over a range from 1,773 to 2,900 K achievable through hardware changes shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR provides

interfaces for PI-provided gas phase field measurements over a range from 1,773 to 2,900 K achievable through hardware changes.

c. The CIR providing interfaces to enable PI-provided spectral filtering of the measurements shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR providing interfaces to enable PI-provided spectral filtering of the measurements.

4.2.1.26.1 Gas phase temperature field measurement sampling rate.

The CIR, to provide a gas phase temperature field measurement sampling rate range from 1- 60 measurements/s shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide a gas phase temperature field measurement sampling rate range from 1 to 60 measurements/s.

4.2.1.26.2 Gas phase temperature field measurement spatial resolution.

a. The CIR capability to provide a gas phase temperature field measurement resolution range from 0.5 to 2 mm shall be verified by test. Verification shall be considered successful when the test shows the CIR provide gas phase temperature field measurement resolution range from 0.5 to 2 mm.
b. The CIR providing interfaces that permit a spatial resolution range from 0.08 to 2 mm to be achievable with hardware changes shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR provides interfaces that permit a spatial resolution range from 0.08 to 2 mm to be achievable with hardware changes.

4.2.1.26.3 Gas phase temperature field measurement lateral field of view.

a. The CIR providing a gas phase temperature field measurement lateral field of view range from 2.9 to 13 cm shall be verified by test. The verification shall be considered successful when the test shows the CIR provides a gas phase temperature field measurement lateral field of view range from 2.9 to 13 cm.
b. The CIR providing interfaces that permit a PI-provided lateral field of view range from 13 to 20 cm to be achievable with hardware changes shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR provides interfaces that permit a PI-provided lateral field of view range from 13 to 20 cm to be achievable with hardware changes.

4.2.1.26.4 Gas phase temperature field measurement axial field of view.

a. The CIR providing a gas phase temperature field measurement PI-provided axial field of view range from 0.5 to 18 cm shall be verified by test. The verification shall be considered successful when the test shows the CIR provides a gas phase temperature field measurement PI-provided axial field of view range from 0.5 to 18 cm.
b. The CIR providing interfaces that permit an axial field of view range from 18 to 20 cm to be achievable with hardware changes shall be verified by inspection. The verification shall be

considered successful when the inspection shows the CIR provides interfaces that permit an axial field of view range from 18 to 20 cm to be achievable with hardware changes.

4.2.1.27 Condensed phase temperature field measurements.

a. The CIR capability to provide condensed phase temperature field measurements from 260 to 1,300 K with temperature resolution range from 5 to 60 K shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide condensed phase temperature field measurements from 260 to 1,300 K with temperature resolution range from 5 to 60 K.
b. The CIR capability to provide a dimensionally controlled positional interface to the combustion chamber shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR provides a dimensionally controlled positional interface to the combustion chamber.
c. The CIR capability to provide interfaces to enable spectral filtering of the measurements shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR provides provide interfaces to enable spectral filtering of the measurements.
d. The CIR capability to provide interfaces so that a PI-provided high resolution condensed phase temperature field measurement capability with a resolution range from 0.2 to 5 K can be achievable with hardware changes shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR provides interfaces so that a PI-provided high resolution condensed phase temperature field measurement capability with a resolution range from 0.2 to 5 K can be achievable with hardware changes.

4.2.1.27.1 Condensed phase temperature field measurement sampling rate.

The CIR capability to provide a condensed phase temperature field measurement sampling rate range from 1 to 60 measurements/s shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide a condensed phase temperature field measurement sampling rate range from 1 to 60 measurements/s.

4.2.1.27.2 Condensed phase temperature field measurement spatial resolution.

a. The CIR capability to provide a condensed phase temperature field measurement resolution range from 0.5 to 2 mm shall be verified by test. Verification shall be considered successful when the test shows The CIR can provide a condensed phase temperature field measurement from 0.5 to 2 mm .
b. The CIR capability to provide interfaces that permit a PI-provided condensed phase temperature field measurement resolution range from 0.2 to 0.5 mm shall be verified by inspection. The verification shall be considered successful when the analysis shows the CIR capability to provide interfaces that permit a PI-provided condensed phase temperature field measurement resolution range from 0.2 to 0.5 mm.

4.2.1.27.3 Condensed phase temperature field measurement lateral field of view.

The CIR capability to provide a condensed phase temperature field measurement lateral field of view range from 2.8 to 12 cm shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide a condensed phase temperature field measurement lateral field of view range from 2.8 to 12 cm.

4.2.1.27.4 Condensed phase temperature field measurement axial field of view.

a. The CIR capability to provide a condensed phase temperature field measurement axial field of view range from 5 to 18 cm shall be verified by test. Verification shall be considered successful when the test shows the CIR can provide a condensed phase temperature field measurement axial field of view range from 5 to 18 cm.
b. The CIR capability to provide interfaces that permit a condensed phase temperature field measurement axial field of view range from 5 to 18 cm shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR capability to provide interfaces that permit a condensed phase temperature field measurement axial field of view range from 5 to 18 cm.

4.2.1.28 Pressure measurements.

The CIR capability, interfacing with applicable PI hardware, to measure pressures inside the combustion chamber from at least four separate locations shall be verified by test. Verification shall be considered successful when the test shows the CIR, with applicable PI hardware, can measure pressures inside the combustion chamber from at least four separate locations.

4.2.1.28.1 Pressure measurement sampling rate.

The CIR capability pressure measurement sampling of 1 measurements/s shall be verified by test. Verification shall be considered successful when the test shows the CIR can perform pressure measurement sampling of 1measurements/s.

4.2.1.28.2 Pressure measurement range.

The CIR capability to measure pressures from 0.01 to 8 atm with the accuracy of $\pm$ 0.005 atm shall be verified by test. Verification shall be considered successful when the test shows the CIR can measure pressures from 0.01 to 8 atm with the accuracy $\pm$ 0.005 atm.

4.2.1.29 Chemical composition measurements.

The CIR capability to sample and measure gases from the combustion chamber shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis shows the CIR can sample and measure gases from the combustion chamber based on the expected gases and their gas concentrations from each basis experiment. Test verification shall be considered successful when the test shows the CIR can sample and measure gases from the combustion chamber based on the expected gases and their gas concentrations from each basis experiment.

4.2.1.29.1 Chemical composition measurement constituents.

a. The CIR capability, with the applicable PI hardware, to measure, as a minimum, the following compounds:

   1. Hydrogen
   2. Methane
   3. Propane
   4. Oxygen
   5. Nitrogen
   6. Carbon monoxide
   7. Carbon dioxide
   8. Sulfur hexafluoride

shall be verified by test. Verification shall be considered successful when the test shows the CIR, with applicable PI hardware, can measure the gases listed above.

b. The CIR providing an interface through the combustion chamber for PI provided water vapor measurement shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR providing an interface through the combustion chamber for PI provided water vapor measurement.

4.2.1.29.2 Gas composition measurement range.

The CIR capability, with the applicable PI hardware, to measure the gas constituents in a range from 0.1 to 100% (± 2% for any measurement within the range) of the measured concentration shall be verified by test. The verification shall be considered successful when the test shows the CIR, with applicable PI hardware, can measure the gas constituents in a range from 0.1 to 100% (± 2% for any measurement within the range) of the measured concentration.

4.2.1.30 Soot measurements.

a. The CIR capability to provide non-intrusive soot volume fraction distribution measurements with a dimensionally controlled positional interface to the combustion chamber shall be verified by test. Verification shall be considered successful when the test shows the CIR capability to provide non-intrusive soot volume fraction distribution measurements with a dimensionally controlled positional interface to the combustion chamber.
b. The CIR capability to provide spectral filtering of the soot volume faction measurements shall be verified by test. Verification shall be considered successful when the test shows the CIR capability to provide spectral filtering of the soot volume faction measurements.
c. The CIR shall provide illumination for the soot volume fraction measurements shall be verified by test. Verification shall be considered successful when the test shows the CIR provides illumination for the soot volume fraction measurements.

d. The CIR capability to provide non-intrusive soot temperature measurements with a dimensionally controlled positional interface to the combustion chamber shall be verified by test. Verification shall be considered successful when the test shows the CIR capability to provide non-intrusive soot temperature measurements with a dimensionally controlled positional interface to the combustion chamber.
e. The CIR capability to provide spectral filtering of the soot temperature measurements shall be verified by test. Verification shall be considered successful when the test shows the CIR capability to provide spectral filtering of the soot temperature measurements.

4.2.1.30.1 Soot volume fraction measurement lateral field of view.

The CIR capability to provide a lateral field of view range from 2.5 to 4 cm with a resolution range from 0.1 to 1 mm shall be verified by test. Verification shall be considered successful when the test shows the CIR capability to provide a lateral field of view range from 2.5 to 4 cm with a resolution range from 0.1 to 1 mm.

4.2.1.30.2 Soot volume fraction measurement axial field of view.

a. The CIR capability to provide an axial field of view range from 0.03 to 8 cm with a resolution range from 0.1 to 3 mm shall be verified by test. Verification shall be considered successful when the test shows the CIR capability to provide an axial field of view range from 0.3 to 8 cm with a resolution range from 0.1 to 3 mm.
b. The CIR capability to provide interfaces that permit a PI-provided axial field of view range from 0.3 to 9 cm achievable through hardware changes shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR capability to provide interfaces that permit a PI-provided axial field of view range from 0.3 to 9 cm achievable through hardware changes.

4.2.1.31 Radiometry measurements.

The CIR capability to provide five interfaces for PI-provided radiometry measurements shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR provides five interfaces for PI-provided radiometry measurements.

4.2.1.32 Velocity point measurements.

a. The CIR capability to provide 20 interfaces for PI-provided velocity point measurements shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR provides 20 interfaces for PI-provided velocity point measurements.

The CIR providing interfaces to support PI-provided particle illumination and illumination delivery devices shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR provides interfaces to support PI-provided particle illumination and illumination delivery devices.

4.2.1.33 Full field velocity imaging.

a. The CIR capability to provide interfaces for full field velocity shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR provides interfaces for full field velocity.
b. The CIR capability to provide interfaces to enable PI-provided spectral filtering of images shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR provides interfaces enable PI-provided spectral filtering of images.
c. The CIR capability to provide interfaces to support PI-provided particle illumination and illumination delivery devices shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR provides interfaces to support PI-provided particle illumination and illumination delivery devices.

4.2.1.33.1 Full field lateral field of view.

The CIR capability to provide interfaces for selecting a lateral field of view range from 2 to 12 cm shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR provides interfaces for selecting a lateral field of view range from 2 to 12 cm.

4.2.1.33.2 Full field axial field of view.

The CIR capability to provide interfaces for selecting an axial field of view range from 2.5 to 16 cm shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR provides interfaces for selecting an axial field of view range from 2.5 to 16 cm.

4.2.1.34 Acceleration measurements.

The CIR capability to monitor residual accelerations and g-jitter from 10^{-6} to 10^{-2} g/g_0 with an accuracy range as specified in SAMS-FF-DOC-101.shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can monitor residual accelerations and g-jitter from 10^{-6} to 10^{-2} g/g_0 with an accuracy range as specified in SAMS-FF-DOC-101.

4.2.1.34.1 Acceleration measurement sampling rate.

The CIR capability to measure the accelerations at a sampling rate of 10, 25, 50, 100, 200, 400, or 800 Hz measurements/s as specified in SAMS-FF-DOC-101 shall be verified by test. Verification shall be considered successful when the test shows the CIR capability to measure the accelerations at a sampling rate of 10, 25, 50, 100, 200, 400, or 800 Hz measurements/s as specified in SAMS-FF-DOC-101.

4.2.1.35 Data time reference.

a. The CIR capability to reference all data, including digital images, to ISS-related mission time shall be verified by test. Verification shall be considered successful when the test shows the CIR can reference all data, including digital images, to ISS-related mission time.
b. The CIR providing an interface to make the time reference available to all applicable PI hardware shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR providing an interface to make the time reference available to all applicable PI hardware.

4.2.1.35.1 Data time reference for experiment events.

a. The CIR capability to have a time reference resolution of ± 0.001 s for experiment events shall be verified by test. Verification shall be considered successful when the test shows the CIR, with applicable PI hardware, can have a time reference resolution of ± 0.001 s for experiment events.
b. The CIR providing an interface to make the time reference available to all applicable PI hardware shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR providing an interface to make the time reference available to all applicable PI hardware.

4.2.1.35.2 Data time reference for external events.

a. The CIR capability to have a time reference resolution of ± 1 s for external events shall be verified by test. Verification shall be considered successful when the test shows the CIR, with applicable PI hardware, can have a time reference resolution of ± 1 s for external events.
b. The CIR providing an interface to make the time reference available to all applicable PI hardware shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR providing an interface to make the time reference available to all applicable PI hardware.

4.2.1.36 Simultaneous measurements.

a. The CIR capability to simultaneously provide up to 8 field measurement interfaces outside the combustion chamber and a minimum of 35 single sensor measurement interfaces inside the combustion chamber shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR can simultaneously provide up to 8 field measurements interfaces outside the combustion chamber and a minimum of 35 single sensor measurement interfaces inside the combustion chamber
b. The CIR capability to simultaneously provide control and measurement interfaces to allow applicable PI hardware to operate inside and outside the combustion chamber shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR can simultaneously provide control and measurement interfaces to allow applicable PI hardware to operate inside and outside the combustion chamber.

4.2.1.37 On-orbit instrument calibration.

The CIR capability to perform on-orbit calibrations of instruments using standards traceable to the National Institute of Standards and Technology (NIST) shall be verified by test. Verification shall be considered successful when the test shows the CIR can perform on-orbit calibrations of instruments using standards traceable to the NIST.

4.2.1.37.1 Replacement of on-orbit instruments.

The CIR capability to replace instruments not capable of being calibrated on orbit with instruments calibrated to standards traceable to NIST shall be verified by demonstration. Verification shall be considered successful when the demonstration shows the CIR can replace instruments not capable of being calibrated on orbit with instruments calibrated to standards traceable to NIST.

4.2.1.38 Rack environment monitoring.

The CIR capability to collect data for downlinking to monitor the pressure, temperature, humidity, and acceleration within the CIR rack environment shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis shows the CIR can measure pressure and humidity from the US Lab environment, correlate the measurements to the CIR rack environment and downlink the data. Test verification shall be considered successful when the test shows the CIR can measure CIR rack temperature and acceleration environments using SAMS Free Flyer and temperature sensors in various locations throughout the CIR rack and downlink the data.

4.2.1.39 On-orbit data storage.

The CIR capability to identify all on-orbit data with test point durations and the number of test points using the capacities as specified in paragraph 3.2.1.22 shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR can identify all on-orbit data with test point durations and the number of test points using the capacities as specified in paragraph 3.2.1.22.

4.2.1.40 On-orbit data collection and transfer.

4.2.1.40.1 Processing and providing data.

a. CIR capability of interfacing with the ISS to allow all on-orbit data transfer for downlinking to the ground for use by the payload equipment and FCF ground crews and for data archiving prior to SAR deployment shall be verified by test and inspection. The verification shall be considered successful when the test shows the CIR capability of interfacing with the ISS to allow all on-orbit data transfer for downlinking to the ground for use by the payload equipment and FCF ground crews and for data archiving prior to SAR deployment and the inspection shows that all data properly transferred.

b. After SAR deployment, the CIR capability to acquire, synthesize, and transfer science performance, configuration, status assessment, and message data to the SAR shall be verified by test and inspection using SAR simulated equipment. The verification shall be considered successful when the test shows the CIR capability to acquire, synthesize, and transfer science performance, configuration, status assessment, and message data to the SAR and the inspection shows that all data transferred properly.
c. Prior to deployment of the SAR, during stand-alone operations, and in case of loss of the SAR to ISS communications, the CIR capability to acquire, synthesize, and present science, performance, configuration, status assessment, and message data to the on-orbit crew in the form of textual and graphic displays to the SSC shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to acquire, synthesize, and present science, performance, configuration, status assessment, and message data to the on-orbit crew in the form of textual and graphic displays to the SSC.
d. Prior to SAR deployment and within the limited volume provided for image processing, the CIR capability of processing scientific and engineering data in order to reduce the real-time, near real-time and post-test bandwidth and duration necessary to transmit the data to the ground through the ISS as specified in paragraph 3.2.1.40.1 d shall be verified by test and inspection. The verification shall be considered successful when the test and inspection meets the requirements as specified in paragraph 3.2.1.40.1 d.
e. The CIR capability to retain all data until commands are received from the FCF ground operations team indicating what data can be deleted or over-written shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to retain all data until commands are received from the FCF ground operations team indicating what data can be deleted or over-written.
f. The CIR capability of providing, when requested by the FCF ground operations team, a summary of all data stored in the CIR, including identification of each measurement, time stamp/duration of data for each measurement, and file sizes shall be verified by test. The verification shall be considered successful when the test shows the CIR capability of providing, when requested by the FCF ground operations team, a summary of all data stored in the CIR, including identification of each measurement, time stamp/duration of data for each measurement, and file sizes.
g. The CIR capability of sending image streams from scientific imaging devices in the CIR to the SAR for image processing and storage shall be verified by test. The verification shall be considered successful when the test shows the CIR capability of sending image streams from scientific imaging devices in the CIR to the SAR for image processing and storage.

4.2.1.40.2 Image control and processing.

a. The CIR capability to provide image and data acquisition for visible imaging that permits storage of image data without compression from 1 to 100 frames/s shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide image and data acquisition for visible imaging that permits storage of image data without compression from 1 to 100 frames/s.
b. The CIR capability to provide image and data acquisition for IR imaging that permits storage of image data without compression from 1 to 60 frames/s shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide

image and data acquisition for IR imaging that permits storage of image data without compression from 1 to 60 frames/s.

c. The CIR capability to provide image and data acquisition for UV imaging that permits storage of image data without compression from 1 to 100 frames/s shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide image and data acquisition for UV imaging that permits storage of image data without compression from 1 to 100 frames/s.
d. The CIR capability to provide image and data acquisition for gas phase temperature measurements that permits storage data without compression from 1 to 1,000 measurements/s/measurement shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide image and data acquisition for gas phase temperature measurements that permits storage data without compression from 1 to 1,000 measurements/s/measurement.
e. The CIR capability to provide image and data acquisition for condensed phase temperature point measurements that permits storage of data without compression from 1 to 30 measurements/s/measurement shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide image and data acquisition for condensed phase temperature point measurements that permits storage of data without compression from 1 to 30 measurements/s/measurement.
f. The CIR capability to provide image and data acquisition for gas phase temperature field measurements that permits storage of image data without compression from 1 to 60 frames/s shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide image and data acquisition for gas phase temperature field measurements that permits storage of image data without compression from 1 to 60 frames/s.
g. The CIR capability to provide image and data acquisition non-intrusive soot volume fraction distribution and soot temperature measurements that permits storage of image data without compression shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide image and data acquisition non-intrusive soot volume fraction distribution and soot temperature measurements that permits storage of image data without compression.
h. The CIR capability to provide data acquisition for radiometry measurements that permits storage data without compression from 1 to 1,000 samples/s shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide data acquisition for radiometry measurements that permits storage data without compression from 1 to 1,000 samples/s.
i. The CIR capability to provide image and data acquisition for full field velocity imaging that permits storage of image data without compression from 30 to 60 frames/s shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide image and data acquisition for full field velocity imaging that permits storage of image data without compression from 30 to 60 frames/s.
j. The CIR capability of controlling a minimum of four image streams shall be verified by test. The verification shall be considered successful when the test shows the CIR capability of controlling a minimum of four image streams.

4.2.1.40.3 On orbit data transfer within FCF.

The CIR capability of accepting and transferring all data to the SAR at a theoretical minimum rate of 100 Mbits/s after SAR deployment shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR capability of accepting and transferring all data to the SAR at a theoretical minimum rate of 100 Mbits/s after SAR deployment.

4.2.1.40.4 On orbit data transfer to portable media.

The CIR capability of transferring all stored data, as specified in paragraph 3.2.1.22 based on the basis experiments as specified in FCF-DOC-002, to portable media shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR capability of transferring all stored data, as specified in paragraph 3.2.1.22 based on the basis experiments as specified in FCF-DOC-002, to portable media

4.2.1.41 CIR health status monitoring.

a. The CIR capability to monitor and transfer on-orbit health status data of all assemblies with electrical and fluids interfaces to the SSC and to the SAR and to transfer on-orbit health status data to the ISS for downlinking when the CIR is powered and note any out-of-tolerance conditions shall be verified by test. Verification shall be considered successful when the test shows the CIR can monitor and transfer on-orbit health status data to the ISS for downlinking of all assemblies with electrical and fluids interfaces to the SSC and to the SAR and downlink on-orbit health status data, noting any out-of-tolerance conditions, when the CIR is powered.
b. The CIR capability to collect and monitor health status data from all applicable PI assemblies and provide this data to the above interfaces shall be verified by test. The verification shall be considered successful when the test show the CIR capability to collect and monitor health status data from all applicable PI assemblies and provide this data to the above interfaces.

4.2.1.41.1 CIR/FCF health status monitoring.

The CIR capability to interface with the SSC, to transfer to the SSC health status data of FCF systems that interface with the CIR, and to transfer the health status data to the ISS for downlinking when the CIR is powered and note any out-of-tolerance conditions shall be verified by test. Verification shall be considered successful when the test shows the CIR can interface with the SSC, can transfer to the SSC health status data of FCF systems that interface with the CIR, and can transfer the health status data to the ISS, noting any out-of-tolerance conditions for downlinking when the CIR is powered.

4.2.1.41.1.1 Health status reporting to SAR.

The capability of reporting out-of-tolerance conditions to the SAR after SAR deployment shall be verified by test using hardware to simulate the SAR. The verification shall be considered successful when the test show the capability of reporting out-of-tolerance conditions to the SAR after SAR deployment.

4.2.1.41.2 CIR/ISS health status monitoring.

The CIR capability to interface with the SSC, to transfer to the SSC its health status data of ISS systems that interface with the CIR, and to transfer the health status data to ISS for downlinking when the CIR is powered, noting any out-of-tolerance conditions, shall be verified by test. Verification shall be considered successful when the test shows the CIR can interface with the SSC, can transfer to the SSC health status data of ISS systems that interface with the CIR, and can transfer the health status data to the ISS for downlinking, noting any out-of tolerance conditions, when the CIR is powered.

4.2.1.42 CIR Commanding.

4.2.1.42.1 SSC Commanding.

a. The CIR capability to accept command inputs, acknowledge and validate the inputs, return responses, and monitor all CIR functions that use the SSC when the CIR is powered shall be verified by test. Verification shall be considered successful when the test shows the CIR can accept command inputs, acknowledge and validate the inputs, return responses, and monitor all CIR functions that use the SSC when the CIR is powered.
b. The CIR capability of routing applicable commands to PI hardware shall be verified by test. The verification shall be considered successful when the test shows the CIR capability of routing applicable commands to PI hardware.

4.2.1.42.2 Ground Commanding.

a. The CIR capability to accept command inputs, to acknowledge and validate the inputs, and to return responses though the ISS-provided interfaces when the CIR is powered shall be verified by test. Verification shall be considered successful when the test shows the CIR can accept command inputs, acknowledge and validate the inputs, and return responses though the ISS-provided interfaces when the CIR is powered.
b. The CIR capability of routing applicable commands to PI hardware shall be verified by test. The verification shall be considered successful when the test shows the CIR capability of routing applicable commands to PI hardware.

4.2.1.42.3 Commanding through SAR.

a. The CIR capability to accept command inputs, to acknowledge and validate the inputs, and to return responses using the SAR when the CIR is powered shall be verified by test. Verification shall be considered successful when the test shows the CIR can accept command inputs, acknowledge and validate the inputs, and return responses using the SAR when the CIR is powered.

b. The CIR capability of routing applicable commands to PI hardware shall be verified by test. The verification shall be considered successful when the test shows the CIR capability of routing applicable commands to PI hardware.

4.2.1.42.4 Manual inputs.

The CIR capability to provide the mechanical (switches, displays, etc.) equipment necessary for the on-orbit crew to control the CIR shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR capability to provide the mechanical (switches, displays, etc.) equipment necessary for the on-orbit crew to control the CIR.

4.2.1.43 Upgrading of CIR maintenance items.

The CIR capability to allow for upgrading of components within the assemblies and other maintenance items within the CIR shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can allow for upgrading of components within the assemblies and other maintenance items within the CIR.

4.2.1.44 Control of CIR.

a. The CIR capability to provide overall control as specified in Table III shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to provide overall control as specified in Table III.
b. The CIR capability to control all payload equipment placed within the CIR shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to control all payload equipment placed within the CIR.

4.2.2 Physical characteristics.

4.2.2.1 CIR dimensional characteristics.

4.2.2.1.1 CIR launch envelope.

The CIR in launch configuration not exceeding the envelope as specified in SSP 41017 Part 1, paragraph 3.2.1.1.2 shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis shows using computer modeling tools and drawings that the CIR in launch configuration does not exceed the envelope as specified in SSP 41017 Part 1, paragraph 3.2.1.1.2. Test verification shall be considered successful when the test shows the CIR in launch configuration does not exceed the envelope as specified in SSP 41017 Part 1, paragraph 3.2.1.1.2.

4.2.2.1.2 CIR on-orbit envelope.

The CIR, with applicable PI hardware, having an on-orbit envelope as specified in SSP 41017 Part 1, paragraph 3.2.1.1.2 and following the on-orbit payload protrusion requirements as specified in SSP 57000, paragraph 3.1.1.7 shall be verified by analysis and test in accordance with SSP 57000, paragraph 4.3.1.1.7. Analysis verification shall be considered successful when the analysis, using computer modeling tools, shows the CIR, with applicable PI hardware, has an on-orbit envelope as specified in SSP 41017 Part 1, paragraph 3.2.1.1.2 and follows the on-orbit payload protrusion requirements as specified in SSP 57000, paragraph 3.1.1.7 drawings in accordance with SSP 57000, paragraph 4.3.1.1.7. Test verification shall be considered successful when the test shows the CIR, with applicable PI hardware, has an on-orbit envelope as specified in SSP 41017 Part 1, paragraph 3.2.1.1.2 and follows the on-orbit payload protrusion requirements as specified in SSP 57000, paragraph 3.1.1.7 in accordance with SSP 57000, paragraph 4.3.1.1.7.

4.2.2.1.3 CIR stowage volume.

a. The CIR not exceeding a maintenance item stowage volume of 0.18 m^3 shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis, using computer modeling tools and drawings, shows the CIR does not exceed a maintenance item stowage volume of 0.18 m^3. Test verification shall be considered successful when the test shows the CIR does not exceed a maintenance item stowage volume of 0.18 m^3.
b. The CIR capability provide a minimum of 0.11 m^3 of space for payload equipment within its envelope with an additional 0.01 m^3 of optionally available for use by payloads if they do not require Flight Segment provided diagnostics shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR capability provide a minimum of 0.11 m^3 of space for payload equipment within its envelope with an additional 0.01 m^3 of optionally available for use by payloads if they do not require Flight Segment provided diagnostics.

4.2.2.1.4 CIR maintenance item stowage up-volume.

The CIR maintenance items not exceeding an up-volume of 1/3 standard rack equivalents shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis, using computer modeling tools and drawings, shows the CIR maintenance items do not exceed an up-volume of 1/3 standard rack equivalents. Test verification shall be considered successful when the test shows the CIR maintenance items do not exceed an up-volume of 1/3 standard rack equivalents.

4.2.2.2 CIR weight characteristics.

a. The CIR not exceeding a launch mass of 804.2 kg (1773 lbs), excluding stowage hardware, shall be verified by analysis and demonstration. Analysis verification shall be considered successful when the analysis, using computer modeling tools, shows the CIR does not exceed a launch mass of 804.2 kg (1773 lbs), excluding stowage hardware. Demonstration verification shall be considered successful when the demonstration, by weighing the actual hardware components and assemblies to within a total CIR of 2.3 kg (5 lbs), shows the CIR does not exceed a launch mass of 804.2 kg (1773 lbs).
b. The CIR, with applicable PI hardware, not exceeding an on-orbit mass of 804.2 kg (1773 lbs), excluding stowage hardware, shall be verified by analysis and demonstration. Analysis

verification shall be considered successful when the analysis, using computer modeling tools, shows the CIR, with applicable PI hardware, does not exceed an on-orbit mass of 804.2 kg (1773 lbs), excluding stowage hardware. Demonstration verification shall be considered successful when the demonstration, by weighing the actual hardware components and assemblies, shows the CIR, with applicable PI hardware, does not exceed an on-orbit mass of 804.2 kg (1773 lbs), excluding stowage hardware.

c. CIR spares and resupply equipment not exceeding an up-mass of 125 kg (312.5 lbs) shall be verified by analysis and demonstration. Analysis verification shall be considered successful when the analysis, using computer modeling tools, shows the CIR spares and resupply equipment do not exceed an up-mass of 125 kg(312.5 lbs). Demonstration verification shall be considered successful when the demonstration, by weighing the actual hardware components and assemblies, shows the CIR spares and resupply equipment do not exceed an up-mass of 125 kg (312.5 lbs).

4.2.2.3 CIR power.

a. The CIR capability, with applicable PI hardware, to use a maximum of 6,000 W of power shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR, with applicable PI hardware, can use a maximum of 6,000 W of power.
b. The CIR capability, with applicable PI hardware, to be integrated into the FCF and not exceed a power draw of 2,000 W shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR, with applicable PI hardware, can be integrated into the FCF and not exceed a power draw of 2,000 W.

4.2.2.3.1 CIR environmental control system power allocation.

The CIR environmental control system power allocation, over a period of 30 minutes, not exceeding 30 W or 8% of the input power to the CIR, whichever is greater, shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis shows the CIR environmental control system power allocation, over a period of 30 minutes, does not exceed 30 W or 8% of the input power to the CIR, whichever is greater. Test verification shall be considered successful when the test shows the CIR environmental control system power allocation, over a period of 30 minutes, does not exceed 30 W or 8% of the input power to the CIR, whichever is greater.

4.2.2.3.2 CIR power to PI avionics.

The CIR capability to provide a minimum of 2 channels of 8A, 28 Vdc power for PI avionics shall be verified by inspection and test. Inspection verification shall be considered successful when the inspection of the CIR drawings show the CIR can provide a minimum of 2 channels of 8A, 28 Vdc power for PI avionics. Test verification shall be considered successful when the test shows the CIR can provide a minimum of 2 channels of 8A, 28 Vdc power for PI avionics.

4.2.2.3.3 CIR power to PI hardware inside combustion chamber.

The CIR capability to provide 3 channels 4A, 120 Vdc and 2 channels 8A, 28 Vdc power to operate experiments within the combustion chamber shall be verified by inspection and test. Inspection verification shall be considered successful when the inspection of the CIR drawings shows the CIR can provide 3 channels 4A, 120 Vdc and 2 channels 8A, 28 Vdc power to operate experiments within the combustion chamber. Test verification shall be considered successful when the test shows the CIR can provide 3 channels 4A, 120 Vdc and 2 channels 8A, 28 Vdc power to operate experiments within the combustion chamber.

4.2.2.4 CIR heat rejection.

The CIR capability to reject a maximum of 6,000 W of power shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR can reject a maximum of 6,000 W of power.

4.2.2.5 PI avionics cooling air.

The CIR capability to provide a minimum of 450 W air cooling to PI avionics shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can provide a minimum of 450 W air cooling to PI avionics.

4.2.2.6 Thermal cooling water.

The CIR capability to provide thermal water cooling with a minimum inlet temperature of 16.1°C (61.0°F) and a maximum outlet temperature of 48.9°C (120°F) shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis shows the CIR can provide thermal water cooling with a minimum inlet temperature of 16.1°C (61.0°F) and a maximum outlet temperature of 48.9°C (120°F). Test verification shall be considered successful when the test shows the CIR can provide thermal water cooling with a minimum inlet temperature of 16.1°C (61.0°F) and a maximum outlet temperature of 48.9°C (120°F).

4.2.2.6.1 Thermal water cooling inside combustion chamber.

The CIR capability to provide an interface for PI thermal water cooling to the interior of the combustion chamber at a minimum of 500 W capacity with a minimum inlet temperature of 16.1°C (61.0°F) and a maximum outlet temperature of 48.9°C (120°F) shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis shows the CIR can provide an interface for PI thermal water cooling to the interior of the combustion chamber at a minimum of 500 W capacity with a minimum inlet temperature of 16.1°C (61.0°F) and a maximum outlet temperature of 48.9°C (120°F). Test verification shall be considered successful when the test shows the CIR can provide an interface for PI thermal water cooling to the interior of the combustion chamber at a minimum of 500 W capacity with a minimum inlet temperature of 16.1°C (61.0°F) and a maximum outlet temperature of 48.9°C (120°F).

4.2.2.7 Durability.

a. The CIR design to have a minimum operational life of 10 years after full deployment of the FCF, including regular scheduled and unscheduled maintenance activities, shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR is designed to have a minimum operational life of 10 years after full deployment of the FCF, including regular scheduled and unscheduled maintenance activities.
b. The CIR design to be capable of an extended life to 15 years after full deployment, including regular scheduled and unscheduled maintenance activities and major component replacement, shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR is designed to be capable of an extended life to 15 years after full deployment, including regular scheduled and unscheduled maintenance activities and major component replacement.

4.2.2.8 Transportation and safety requirements.

Not applicable.

4.2.2.9 Interfaces.

4.2.2.9.1 Interfaces within the US Lab.

a. Verification that the CIR connectors physically mate with the corresponding module connector shall be verified by demonstration. The demonstration shall use module connectors with the part numbers specified in Table I and Table II to verify that the connectors physically mate. The verification shall be considered successful when the demonstration shows the integrated rack connectors physically mate with its corresponding module connectors.
b. A demonstration shall be conducted using the Payload Rack Checkout Unit (PRCU) or equivalent to show that the umbilicals can successfully reach their intended connector and to observe that the connectors are in a fully mated condition.
c. Verification that the internal interfaces are as specified in paragraph 3.2.2.9.1 shall be verified by inspection of the CIR drawings. The verification shall be considered successful when the inspections of the drawings show that the internal interfaces are as specified in paragraph 3.2.2.9.1.

4.2.2.9.2 Ground support equipment (GSE) interfaces.

a. Interface compatibility to KSC GSE Rack Insertion Device shall be verified by inspection of the CIR design drawings. Verification shall be considered successful when inspection of the drawings show the interface is compatible with the drawings in SSP 41017. The NASA provided 683–50243–4 ISPR structure is assumed to meet these interfaces, provided that the integrated rack hardware does not exceed the static envelope requirement.
b. CIR interfaces with the RSC shall be verified by a fit check demonstration. The demonstration shall be considered successful when it shows that the CIR can be successfully connected to the RSC. The NASA provided 683–50243–4 ISPR structure is assumed to meet

these interfaces, provided that the integrated rack hardware does not exceed the static envelope requirement.

c. CIR compatibility with the RHA shall be verified by a fit check demonstration. The demonstration shall be considered successful when it shows that the CIR can be successfully connected to the RHA. The NASA provided 683–50243–4 ISPR structure is assumed to meet these interfaces, provided that the CIR does not exceed the static envelope requirement.
d. Ground transportation acceleration limits shall be verified by test and analysis. The test and analysis shall be considered successful when the test provides a measurement of the maximum accelerations encountered during shipment in the 3 orthogonal rack axes and an analysis shows that these accelerations do not exceed 80% of the flight accelerations.

4.2.2.9.3 MPLM interfaces.

a. Structural attach point compatibility shall be verified by inspection of the CIR drawings and comparison with the table referenced in SSP 41017. The NASA provided 683–50243–4 ISPR structure is assumed to meet these interfaces.
b. An analysis shall be conducted which determines the maximum delta pressure from inside to outside of the CIR and shows that the CIR rack maintains positive margins of safety (delta pressure limited to 3.5 kPa (0.5 psi)). Verification shall be considered successful when the analysis shows that 3.5 kPa (0.5 psi) delta pressure is not exceeded. (Verification may be by inspection of CIR design drawings for NASA provided 683–50243–4 ISPR's with intact and unblocked pressure relief valves.)
c. An analysis shall be conducted using the referenced acceleration data and calculating the interface attach point loads via finite element modeling (FEM). The analysis shall be considered successful when the FEM is approved by the ISS program and it calculates attach point loads that do not exceed the MPLM allowable limits. A coupled loads analysis will be conducted by the ISS program using the FEM provided to ensure that MPLM allowables are not exceeded when coupled loads are taken into account.

4.2.2.9.4 ISS fluids and vacuum interface requirements.

4.2.2.9.4.1 Water Thermal Control System (WTCS).

a. WTCS fluid use verification that the coolant contained in the integrated rack interfacing with ITCS coolant satisfies the TCS coolant verification test requirements specified in SSP 30573 shall be by test. The verification shall be considered successful if the test results show the CIR coolant meets the TCS coolant requirements in SSP 30573.
b. WTCS charging verification shall be verified by analysis and certificate of compliance stating the amount of coolant charged into the CIR allows for thermal expansion during transport. The verification shall be considered successful if the amount of coolant charged into the CIR allows for thermal expansion when exposed to the temperature range encountered during transport.
c. Verification that the pressure differential measured across the ITCS supply and return interfaces for the flow rates in the range to be used in flight shall be by test with both halves of each mated QD pair included as part of the payload pressure differential. A curve of flow rate versus pressure drop will be generated for each flow configuration and mode of

operation. The verification shall be considered successful if the test results are within the pressure drop requirements specified in Figure 8.

d. Verification of compatibility with the design flow rate shall be by analysis or test using the PRCU or equivalent test equipment. The payload developer shall provide the PRCU or equivalent test equipment flow rate measurements for all modes of operations. The verification shall be considered successful if the analysis or test results provide the integrated rack flow rate measurements for all modes of operation at or below the coolant flow rate limits specified in Figure 8.

e. NVR.

f.
   1. Verification that the initial configuration of the CIR moderate differential return temperature is above the minimum allowable shall be verified by test and analysis. The test shall utilize a PRCU (or equivalent) to measure the differential temperature for the minimum, maximum, and nominal power modes of the CIR. Analysis shall be used to account for any on-orbit modifications of equipment, using a thermal model adjusted with the results from the CIR return temperature testing, to verify that the changes in equipment satisfy the minimum differential temperature. The verification shall be considered successful when the initial test and subsequent analysis show that the moderate differential return temperature is above the minimum allowable.
   2. Verification that the CIR using moderate temperature coolant is designed to operate using 100 lbm/h flow during modes of operation which require less than 1025 W of power shall be verified by analysis. The verification shall be considered successful when the analysis shows that the CIR using moderate temperature coolant is designed to operate using 100 lbm/h flow during operating modes which require less than 1025 W of power.
   3. Verification that the initial configuration of the CIR moderate TCS return temperature does not exceed the maximum specified temperature shall be verified by test and analysis. The test shall utilize a PRCU (or equivalent) to measure the outlet temperature for the maximum and nominal power modes of the CIR. Analysis shall be used to account for any on-orbit modifications of equipment, using a thermal model adjusted with the results from the CIR return temperature testing, to verify that the changes in equipment do not exceed the allowable return temperature. The verification shall be considered successful when the initial test and subsequent analysis show that the moderate temperature return limit is not exceeded.

g. The pressure integrity of integrated rack volumes connected to the TCS moderate temperature loop shall be verified by performing a leak-check of the pressure system. The verification shall be considered successful if the test results show the integrated rack passes the leak-check performed at a minimum of 1.0 x MDP per SSP 52005, paragraph 5.1.3.

h. Verification that payload equipment and rack internal water loop piping utilizing the ISS or payload-provided heat rejection system(s) is fail safe in the case of loss of cooling under all modes of operation and will not result in over-temperature, over-pressurization, fire, explosion, release of hazardous or toxic materials, or damage that could propagate to other systems shall be by analysis. If loss of cooling results in a hazard, the controls for shutdown must be verified by test. The verification shall be considered successful if the analysis and/or test results show the integrated rack satisfies the fail safe design criteria.

i. Verification that each ITCS fluid loop including all payload equipment and connections as well as the supply and return interfaces and connections at the Utility Interface Panel does not exceed the leakage requirement shall be by test. The leakage test shall be performed at MDP or above. If helium, or some other medium, is used in testing, the results shall be converted to an equivalent water leakage. The verification shall be considered successful if the test results show the CIR leakage rate to be equal to or less than 14 X 10 -3 SSC/h of liquid per each thermal loop.

NOTE: A conversion factor of 1 SSC/h of water = 233 SSC/h of helium at a pressure of 121 psia shall be used when converting helium leakage to an equivalent water leakage.

j. Verification that air inclusion into the QD during coupling and uncoupling does not exceed 0.3 cc per couple/uncouple cycle shall be by test or analysis of QD certification data. If air is not used in testing of the QD, the results shall be converted to an equivalent volume of air. The verification shall be considered successful if the test results show the integrated rack QD air inclusion does not exceed 0.3 cc per couple/uncouple cycle.
k. Verification that the payload control system time constant is of the specified duration shall be by test. The verification shall be considered successful if the test results show the integrated rack time constant for set point changes resulting in flow rate changes greater than 5 lbm/h shall take the specified time to reach 63.2% (i.e., 1-e-1) of the commanded change in flow rate.
l. Verification that the maximum allowable payload coolant quantity is not exceeded shall be by test or analysis of the payload design drawings. The verification shall be considered successful if the test or analysis results show the integrated rack coolant quantity to be within the limits of no more than the maximum allowable coolant quantity of water, referenced at 61? C (141.8? F). The maximum allowable coolant quantity of water in the US Lab MTL is 42.25 gal. (159.9 L).
m. Verification that the maximum allowable payload gas inclusion or volume limit is not exceeded shall be by analysis of the payload design drawings. The verification shall be considered successful if the analysis results show the integrated rack gas inclusion amount to be within the maximum allowable gas inclusion or volume at the maximum design pressure into the US Lab Internal Thermal Control System of 8.88 in3 (0.146 L).
n. The CIR shall verify by demonstration or inspection that the WTCS interfaces with the Fluid System Services. The verification shall be considered successful when the demonstration or inspection shows the WTCS interfaces with the Fluid System Services.

4.2.2.9.4.2 Vacuum exhaust system/waste gas system (VES/WGS) requirements.

a. CIR vented gas pressure shall be verified by test and analysis. The test shall utilize a PRCU or equivalent to measure the vented gas pressure at the interface plane. The CIR volumes that are connected to ISS VES/WGS shall be pressurized to the expected experiment pressures for the test.
b. The MDP of CIR volumes connected to the VES shall be verified by the test and analysis guidelines identified in SSP 52005, paragraph 5.1.3
c. An analysis shall determine whether or not the CIR (including the experiment chamber) connected to the ISS VES/WGS system provides a two fault tolerant design to prevent venting gases at pressures greater than 276 kPa (40 psia) at the rack to ISS interface. Verification shall be considered successful when the analysis shows the CIR provides a two fault tolerant design to prevent venting gases to the ISS VES/WGS system at pressures greater than 276 kPa (40 psia) at the CIR to ISS interface.

d. CIR temperature shall be verified by test. The test shall utilize a PRCU or equivalent to measure the temperature at the interface plane. The CIR volumes that are connected to VES shall be pressurized to the expected pressures for the test. The experiment shall be subjected to the same heat generating operations that will be experienced on orbit and vented at the same relative time during the experiment operation as would be experienced on orbit.
e. CIR dewpoint shall be verified by test. The test shall utilize a PRCU or equivalent to measure the dewpoint at the interface plane. The CIR volumes that are connected to VES shall be pressurized to the expected pressures for the test. The experiment shall be subjected to the same operations that will be experienced on orbit and vented at the same relative time during the experiment operation as would be experienced on orbit.
f. Verification that exhaust gases vented into the Vacuum Exhaust System/Waste Gas System (VES/WGS) of the US Lab are compatible with the wetted surface materials of the respective laboratory(ies) in which the CIR will operate shall be by analysis or test. Gases documented in SSP 57000 Appendix D have been analyzed for compatibility with the ISS VES/WGS wetted materials. The CIR provider shall submit a complete list of all proposed vent gas constituents, initial volume, concentration, temperature, and pressure to the ISS program. The list submitted shall also identify which exhaust gases will be vented together and shall include the products of any reactions determined in paragraph 3.2.2.9.4.2 g. The ISS module integrator will analyze the list of vent gases not specified in Appendix D and the VES/WGS wetted surface materials to determine whether or not the proposed exhaust gases are compatible with the ISS VES/WGS wetted materials. The ISS program will evaluate and conduct a test if necessary for gases that do not have compatibility documentation to determine whether or not the proposed exhaust gases are compatible with the VES/WGS wetted surface materials. The CIR developer shall review the CIR proposed vent gases and determine whether or not the gases are listed as acceptable in Appendix D or on the report provided by the program in the stage analysis. Verification shall be considered successful when the proposed exhaust gases are shown to be compatible with the ISS VES/WGS wetted surface materials of the respective laboratory(ies) in which the CIR will operate as specified in SSP 57000 Appendix D or in the analysis report from the ISS program. The verification process performed by the ISS program is documented in SSP 57011, Figure 3.4.11–9.
Note: This analysis/test will consider flammability, pitting and general corrosion, and degradation and swelling of seal materials. An analysis will consist of a literature search that will review technical documentation for documented compatibility of exhaust gases with the wetted materials listed in SSP 41002, paragraph 3.3.7.2. Materials and gases will be considered compatible if the documentation shows one of the following: existing use of the material in a system containing the gas in question, test data showing compatibility, or general materials information stating compatibility. For exhaust gases where no technical data showing compatibility is found, a test will be conducted. The test will review material weight loss, wetted material surface changes, soft material swelling, and wetted material trace contaminate inclusion in the test gases after exposure to the materials.
g. Verification that CIR gases vented to the ISS VES/WGS are non-reactive with other vent gas mixture constituents shall be by analysis. An analysis shall determine what gases will be vented to the ISS VES/WGS and, assuming the worst case reactions possible, shall determine all reactions that are possible among the vent gas constituents. An analysis shall calculate the worst case temperature change associated with the possible vent gas reactions in accordance with the equation:

$$20 \geq \frac{\sum_{\text{ALL REACTIONS}} \left[\left[\frac{(\Sigma x_p H_p - \Sigma x_{r1} H_r)}{n_{lim}} \right] m_{lim} \right]}{\Sigma x_p m_p c_{pp} + \Sigma x_{r2} m_r c_{pr} + \Sigma x_d m_d c_{pd}}$$

Hp = Enthalpy of formation of the products (J/mol)
H = Enthalpy of formation of the reactants (J/mol)
Xr1 = Number of moles of the reactants
Xr2 = Number of moles of the unreacted reactants
Xp = Number of moles of the products
Xd = Number of moles of the diluent.
Nlim = Molecular Weight of the limiting reactant in the reaction (g/mol)
mlim = Mass of the limiting reactant in the reaction (g)
mp = Mass of each product gas in the vent mixture (g)
mr = Mass of each unreacted reactant gas in the vent mixture (g)
md = Mass of each diluent gas in the vent mixture (g)
cpp= Constant Pressure Heat Capacity of each product gas at the vented condition (J/(g*K))
cpr = Constant Pressure Heat Capacity of each unreacted gas at the vented condition (J/(g*K))
cpd= Constant Pressure Heat Capacity of each diluent gas at the vented condition (J/(g*K))

Note: The exact equation used may vary slightly depending on the units of the data available for the given gases. These variations shall be limited to unit conversions only. The final units of the equation should be a measure of temperature, measured in Celsius or Kelvin. For each possible reaction in the vent gas mixture, all gases associated with the reaction shall be included in the calculation in the numerator. All possible reactions in the vent gases mixture shall be calculated and summed together in the numerator. All gases in the vented mixture should be included in the denominator of the analysis. Unreacted reactants may be summed in the denominator as a diluent, when rich or lean mixtures are expected for a given reaction. When lean or rich mixtures are expected for one reaction, an analysis shall show that the excess reactant gases will not react with another gas in the vent mixture (the original reaction considered should be the worst case reaction, i.e. most energy released). If trace elements (up to the SMAC value) are present and do not participate in a reaction, they may be excluded from this analysis. Verification shall be considered successful when the analysis shows the gases vented to the ISS VES/WGS are nonreactive according to the equation specified above (the equation meets the inequality).

Note: Venting of cabin air; the ISS pressurized gases, nitrogen, carbon dioxide, argon, or helium; or mixtures of these gases is considered acceptable and does not require verification if each is not mixed with other gases.

h. Verification that CIR venting to the ISS VES/WGS provides a means of removing gases that would adhere to the VES/WGS tubing walls at a wall temperature of 4°C (40°F) and a pressure of 10 (-3) torr shall be by analysis. An analysis shall determine whether or not the gas mixture contains gases with a molecular weight greater than 75 amu or gases which have a boiling point greater than 100°C (212°F) at atmospheric pressure. Each proposed vent gas with a molecular weight greater than 75 amu or a boiling point greater than 100°C (212°F) at atmospheric pressure shall be analyzed to determine whether or not the vapor pressure is below a pressure of 10 (-3) torr at 4°C (40°F). This analysis shall be conducted gas-by-gas. If any proposed vent gases are determined to have a vapor pressure below 10 (-3) torr at 4°C (40°F), an analysis shall be conducted to determine whether or not the CIR provides a means to remove these gases from the vent gas mixture prior to venting to the ISS VES/WGS. Or alternatively, each proposed vent gas with a molecular weight greater than 75 amu or a boiling point greater than 100°C (212°F) at atmospheric pressure shall be analyzed to determine whether or not the boiling temperature is above 4°C (40°F) at a pressure of 10 (-3) torr. This analysis shall be conducted gas-by-gas. If any proposed vent gases are determined to have a boiling temperature above 4°C (40°F) at 10 (-3) torr, an analysis shall be conducted to determine whether or not the integrated rack provides a means to remove these gases from the vent gas mixture prior to venting to the ISS VES/WGS. The Clausius–Clapeyron equation or Antoines equation may be used to verify this requirement. Note that it is not required to use these equations, but they may be helpful. Verification shall be considered successful when the analysis shows the gases that will be exposed to the ISS VES/WGS will not adhere to the ISS VES/WGS tubing walls at a wall temperature of 4°C (40°F) at 10 (-3) torr. Gases that will be exposed to the ISS VES/WGS will not adhere to the ISS VES/WGS tubing walls when each vent gas is shown to have a vapor pressure above 10 (-3) torr or 4°C (40°F) or a boiling temperature below 4°C (40°F) at a pressure of 10 (-3) torr and/or, any gases found with a vapor pressure below 10 (-3) torr at 4°C (40°F) or a boiling temperature above 4°C (40°F) at a pressure of 10 (-3) torr are removed from the gas mixture. Note: Cabin air and the ISS pressurized gases, nitrogen, argon, helium and carbon dioxide, may be vented to the ISS VES/WGS without verification of this requirement.
i. Verification that the CIR venting to the ISS VES/WGS remove particulates from vent gases that are larger than 100 μm shall be by analysis. An analysis shall determine whether or not the vent gases will contain particulate contamination larger than 100 microns. Should the analysis show that particulate contamination greater than 100 microns will be introduced into, or generated in, the vent gases, an analysis shall determine whether or not a means or removing the particles above 100 microns before venting to the ISS VES/WGS is included in the CIR design. Verification shall be considered successful when the analysis shows the vent gases will not contain particulate contamination greater than 100 microns. Note: Cabin air and the ISS pressurized gases, nitrogen, argon, helium and carbon dioxide, may be vented to the ISS VES/WGS in the condition delivered to the CIR if it is shown that particulate contamination is not generated within the CIR.
j. NVR.
k. Verification shall be by analysis. The CIR provider shall submit the list of vented gas constituents, volume, initial temperature, and pressure to the ISS program. The verification shall be considered successful when the Environments Team verifies that the vented gases do not exceed the external contamination limits in the specified section of SSP 30426.

l. NVR.
m. Verification shall be by inspection and analysis. The inspection shall consist of verification that gas containment volume is provided for incompatible gases. The analysis shall verify that the containment volume is sufficient to contain the gas and complies with the pressure vessel requirements identified in SSP 52005, paragraph 5.1.3. The method of transportation of containment volume from on orbit to ground shall be identified.

4.2.2.9.4.3 Vacuum resources system (VRS).

The CIR providing the physical interface to the VRS shall be verified by inspection. The inspection shall be considered successful when inspection shows the correct interface to the ISS VRS has been installed.

4.2.2.9.4.4 ISS nitrogen usage requirements.

a. Verification of nitrogen flow control shall be by test. The verification shall be considered successful when the test results confirm that the CIR can turn on and off the flow of nitrogen and can control the flow to not exceed the maximum allowable nitrogen flow rate when connected to nitrogen supplied at the maximum and minimum of the specified pressure range.
b. The MDP of CIR volume connected to the nitrogen system shall be verified by the test and analysis guidelines identified in SSP 52005, paragraph 5.1.3. The verification shall be considered successful if the test results show the CIR passes the proof-pressure test.
c. Verification that the CIR nitrogen system is compatible with the nitrogen interface temperature range shall be by test or analysis or both. The verification shall be considered successful when review of nitrogen system components, including component qualification data packs or test results, show that the CIR nitrogen system is compatible with the nitrogen temperature range specified.
d. Verification of CIR nitrogen leakage shall be by test. The verification shall be considered successful when the test results show that the sum of all potential leakage sources from the standoff UIP panel connection to the point to nitrogen flow control in the CIR does not exceed the allowable leakage rate.

4.2.2.9.5 COF interfaces.

The CIR capability to interface with the COF for structural, fluids, and electrical connections shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR can interface with the COF for structural, fluids, and electrical connections.

4.2.2.9.6 CIR to SAR interface.

The CIR use of an adapter, part no. MTP-ADPT connected to a MTFA-12M5 ferule inside a MTP-012M-SM housing to interface with the SAR to transfer data and receive commands from the SAR as described in paragraph 3.1.5.1 shall be verified by inspection and test. The inspection verification shall be considered successful when the inspection shows the CIR uses an adapter, part no. MTP-ADPT connected to an MTFA-12M5 ferule inside a MTP-012M-SM housing. The test verification shall be considered successful when the test shows the CIR transfers the data as specified in paragraph 3.1.5.1.

4.2.2.9.7 SAMS data interface.

<TBD 04-02>

4.2.2.9.8 Use of FIR hardware.

The CIR not precluding of the use of FIR hardware to meet science and project requirements shall be verified by analysis. The verification shall be considered successful when the analysis shows that the FIR hardware use was considered to meet CIR science and project requirements.

4.2.3 Reliability.

Not applicable.

4.2.4 Maintainability.

The CIR not exceeding <TBD 04-03> on-orbit MMCH/Y for scheduled and unscheduled maintenance activities including inspections, preventative and corrective maintenance, restorations, and replacement of assemblies and components shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR does not exceed <TBD 04-03> on-orbit MMCH/Y for scheduled and unscheduled maintenance activities including inspections, preventative and corrective maintenance, restorations, and replacement of assemblies and components.

4.2.4.1 CIR maintenance access.

The CIR capability to allow replacement of ORU’s and failed components and performance of other internal maintenance activities without rotating the CIR from its installed position within the US Lab shall be verified by demonstration with the exceptions as noted in Appendix F. Verification shall be considered successful when the demonstration shows the CIR can allow replacement of ORU’s and failed components and performance of other internal maintenance activities without rotating the CIR from its installed position within the US Lab with the exceptions as noted in Appendix F.

4.2.4.2 Maintenance item temporary restraint and stowage.

CIR maintenance items designed to allow for temporary restraint and/or stowage during maintenance activities shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR maintenance items are designed to allow for temporary restraint and/or stowage during maintenance activities.

4.2.4.3 Tool usage for maintenance.

The CIR capability to be maintained using the ISS tools as defined in SSP 57020 shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can be maintained using the ISS tools as defined in SSP 57020.

4.2.4.4 Lockwiring and staking.

Verification that all CIR maintenance items are not lockwired or staked during installation shall be by inspection. Verification shall be considered successful when the inspection shows all CIR maintenance items are not lockwired or staked.

4.2.4.5 Redundant paths.

The CIR capability, with applicable PI hardware, to provide alternate or redundant functional paths of all electrical and electronic harnesses that cannot be replaced on orbit shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR, with applicable PI hardware, can provide alternate or redundant functional paths of all electrical and electronic harnesses that cannot be replaced on orbit.

4.2.4.6 CIR reconfiguration for out-of tolerance conditions.

The CIR capability, with applicable PI hardware, to allow visual and tactile access to all avionics hardware for at least one hour during troubleshooting operations without detrimental effects to the crew, the ISS, or CIR hardware shall be verified by test. Verification shall be considered successful when the test shows the CIR, with applicable PI hardware, can allow visual and tactile access to all avionics hardware for at least one hour during troubleshooting operations without detrimental effects to the crew, the ISS, or CIR hardware.

4.2.5 Availability.

The CIR, with applicable PI hardware and spares, operational availability of 92.92% for a base operational life of 10 years with an extendable life to 15 years, in accordance with the formula:

A0 = MTBM/MTBM+MDT

Where MTBM = Mean Time Between Maintenance and MDT = Mean Delay Time.

shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR, with applicable PI hardware and spares, has an inherent availability of 92.92%.

4.2.6 Environmental conditions.

4.2.6.1 Shipping and storage environment.

4.2.6.1.1 Nonoperating atmospheric environment.

a. The CIR nonoperating temperature range from 2 to 50°C (35.6 to 122°F) shall be verified by test. Verification shall be considered successful when the test shows the CIR can operate during thermal cycle testing after exposure to a nonoperating temperature range from 2°C (35.6°F) to 50°C (122°F).
b. The CIR nonoperating pressure range from 0 to 104.8 kPa shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can operate after exposure to a nonoperating pressure range from 0 to 104.8 kPa.
c. The CIR nonoperating relative humidity range from 10 to 90% shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can operate within its designed operating humidity range after exposure to a nonoperating relative humidity range from 10 to 90%.

4.2.6.1.2 Operating atmospheric environment.

a. The CIR operating temperature range from 17 to 30°C (35.6 to 122°F) shall be verified by test. Verification shall be considered successful when the test shows the CIR can operate during thermal cycle testing after exposure to a nonoperating temperature range from17 to 30°C (35.6 to 122°F).
b. The CIR operating pressure range from 95.8 to 104.8 kPa shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can operate after exposure to a nonoperating pressure range from 95.8 to 104.8 kPa.
c. The CIR operating relative humidity range from 25 to 75% shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR can operate within its designed operating humidity range after exposure to a nonoperating relative humidity range from 25 to 75%.

4.2.6.2 MPLM/on-orbit environmental conditions.

The CIR capability, with the applicable PI hardware, to operate within the MPLM/on-orbit environmental conditions as specified in Table IV shall be verified by analysis. The verification shall be considered successful when analysis shows that the CIR, with the applicable PI hardware, can operate in the MPLM/on-orbit environmental conditions as specified in Table IV.

4.2.6.3 On-orbit condensation.

The CIR design to not cause condensation when exposed to the ISS atmosphere ranging in dewpoint from 4.4 to 15.6°C (40 to 60°F) and in relative humidity from 25 to 75% shall be verified by analysis. The verification shall be considered successful when the analysis shows that no internal or external surfaces in contact with the ISS cabin air will allow condensation when humidity and dewpoint are within the ISS atmosphere envelope defined by Figure 10. Surfaces shall be considered to be in contact with the ISS cabin air unless a volume is hermetically sealed or environmentally conditioned to control humidity.

4.2.6.4 Special environmental conditions.

4.2.6.4.1 Load requirements.

a. An analysis shall be conducted which uses the referenced acceleration data and determines CIR structure loads via FEM. The analysis shall be considered successful when the FEM is approved by the ISS program and the model determines CIR structure loads that maintain positive margins of safety, based upon the rack structure allowable identified in SSP 57007.
b. An analysis shall be conducted to verify that the CIR will maintain positive margins of safety during a transient or continuous on-orbit load of 0.2 g acting in any direction.
c. The CIR design drawings shall be inspected to ensure that hardware is provided for restraint of RUP umbilicals during launch and landing.
d. An analysis shall be performed to show that CIR equipment exposed to the crew translation path maintains a positive margin of safety when exposed to the crew-induced loads as defined in Table VI. The verification shall be considered successful when the analysis shows positive margins exist for yield and ultimate loads for utility lines and for ultimate loads for all other exposed equipment.
e. An analysis shall be performed to show that the components mounted to ISPR posts maintain positive margins of safety for the MPLM launch random vibration environment per Table VII or Table VIII. This analysis shall follow the guidelines provided in SSP 52005, paragraphs 4.1.2 and 4.1.5. The verification shall be considered successful when the analysis shows that components mounted to ISPR posts maintain positive margins of safety.
f. An analysis shall be performed to show that the components mounted to the ISPR’s maintain positive margins of safety after exposure to the design load factors for launch and landing environments per Table IX. This analysis shall follow the guidelines provided in SSP 52005, paragraphs 4.1.2 and 4.1.3. The verification shall be considered successful when the ISS-performed coupled loads analysis shows that the components mounted to the ISPR’s maintain positive margins of safety. Random vibration criteria for ISPR post-mounted equipment weighing 100 pounds or less in the MPLM.

4.2.6.4.2 Rack requirements.

a. An analysis shall be conducted which determines the maximum delta pressure from within to outside the CIR and shows that the CIR maintains positive margins of safety (delta pressure limited to 3.5 kPa (0.5 psi)). Verification shall be considered successful when the analysis shows that 3.5 kPa (0.5 psi) delta pressure is not exceeded. (Verification may be by inspection of CIR design drawings for NASA provided 683–50243–4 ISPR’s with intact and unblocked pressure relief valves.)
b. An analysis shall be conducted using the guidelines provided in SSP 52005 Appendix C.1.2.2. A modal survey test shall be performed to verify the analysis. The verification shall be considered successful when the analysis shows that the CIR and kneebrace meet the frequency requirement specified, and the modal survey test shows the CIR and kneebrace meet the frequency requirement specified.

c. Information – no verification required.
d. Verification shall be by inspection or analysis of the umbilical routing drawing to ensure that the keep-out zone is provided. The verification shall be considered successful when the inspection shows that the envelope (or keep-out zone) is provided, or analysis shows that the umbilicals can be moved out of the envelope without exceeding any umbilical bend radii requirements.
e. An analysis shall be conducted using CIR and module data to evaluate the maximum rotation angle of the CIR rack. The verification shall be considered successful when the rotation angle is calculated to be at least 80 degrees.
f. An analysis shall be conducted which determines the maximum delta pressure from within to outside the CIR during PFE discharge, shows that the CIR maintains positive margins of safety (delta pressure limited to 3.5 kPa (0.5 psi)), and shows that CIR equipment maintains positive margins of safety. Verification shall be considered successful when the analysis shows that the structures maintain positive margins.
g. Verification of CIR positional and crew restraints at rotation angles shall be by analysis. The analysis shall show the use of restraints to maintain the CIR in the position required for payload operations and maintenance. Verification shall be considered successful when the analysis shows that the ISS provided hardware can secure the CIR in the required rotation positions.
h. Verification that the CIR does not have a pressure relief device on the front of the rack shall be by inspection. Verification shall be considered successful when the inspection shows the CIR does not have a pressure relief device on the front of the rack.
i. Verification that the CIR is designed in accordance with the requirements specified in SSP 52005 shall be by inspection. Verification shall be considered successful when the inspection shows that the requirements as specified in SSP 52005 are met. Data certification that provides a summary of margins for all safety critical structures identified in accordance with SSP 52005 using design loads shall be sent to the ISS Program Office no later that L-22 months. Data certification that provides a summary of the margins of safety for all safety critical structures identified in accordance with SSP 52005 using loads from Design Loads Analysis results shall be sent to the ISS Program Office no later then L-12 months. Data certification that provides a summary of the margins of safety for all safety critical structures identified in accordance with SSP 52005 using loads validated by the Verification Lads Analysis results shall be sent to the ISS Program Office no later than L-5 months.
j. Forces produced by a payload below 0.01 Hz shall be verified by analysis against paragraph 3.2.6.4.2 j. This analysis shall be considered successful when it is shown that no impulse is exerted by the payload to the ISS, either directly or through the ISS vent/exhaust systems, greater than 10 lb-s (44 N-s) over any 10 to 500 second interval.
k. Verification of CIR mechanical vibration against paragraph 3.2.6.4.2 k shall be accomplished by FEM, Statistical Energy Analysis (SEA), test, or simplified analysis as discussed in the following paragraphs. SEA may be performed where sufficient modal density is present as defined by the SEA parameter limitations explanation included with the SEA model. FEM analysis may be performed to either the ISS side of the rack attachment brackets interface using a force limit requirement of Table X or to an assumed adjacent ARIS rack interface using the interface acceleration limit requirement of Table XI. In applying these methods, the following are to be observed:

1. CIR FEM models must use a damping factor of 0.5% unless alternative damping values are shown appropriate by test. Damping coefficient test data must be obtained using force levels no greater than the maximum disturbance force allowable to meet microgravity requirements and at the approximate location for the CIR disturbance. High strain producing test methods are to be avoided since such test may increase damping, leading to misleading results.
2. The one-third octave force limits include allowance for CIR frequency deviation as large as 10% from predicted or measured values. If the CIR has a disturbance frequency variation and uncertainty which exceeds 10% shall use worst-case assumptions for frequency disturbances close to one-third octave boundaries.
3. If multiple disturbance sources that are not phase synchronized are modeled, then the effect of each source operating independently is to be added in RSS fashion. If the disturbance sources are phase synchronized then the sum of the vibration contributions for each disturber in phase must be added at each resultant point in each axis prior to obtaining the RSS.
4. To ensure capture of modal peak responses in finite element frequency domain verification procedures, the transfer function and/or response analysis should explicitly include the modal frequencies of the finite element model. These should be supplemented with additional frequencies to adequately capture off-peak responses. It is required that the supplemental frequency density be sufficient to include at least one additional frequency within the half-power bandwidth of the modes. A constant logarithmic frequency spacing in which the delta frequency factor (deltafreq=deltafreqfac*lastfreq) is less than the half-power bandwidth (halfpowbw=2*c/ccrit) provides such a condition.
5. For the frequency range above 50 Hz, either SEA or FEM may be used. SEA models shall use a loss factor coefficient of 0.5% unless alternative values are justified by payload test. FEM models are to be used to the highest frequency verified by test. FEM models may also be used beyond the range verifiable by test to envelope possible rack response as an alternative to SEA. The RSS of each one-third octave band plus one fourth of the RSS of each adjacent band as obtained by rack models applied to measured rack disturbances may be used to envelope FEM force response in the extended frequency range. Test data analysis may be used to adjust the damping coefficient used in either FEM or SEA models or to adjust the coupling coefficients and loss factor used for SEA models.
6. Disturbance forces must be applied to transfer functions from Force Spectral Density (FSD) form for each one-third octave. The RSS value for each incremental division of FSD (f) contribution of multiple sources, wide-band and narrow-band, are to be added to yield a total FSD (f) for each frequency subdivision before Frms is calculated. Values are given either as wide-band (an rms value and a frequency range) or as narrow-band (an rms value and a discrete frequency). Wide-band rms one-third octave data are to be converted to FSD (f) per the following equation:

$$\mathrm{FSD}(f) = \frac{\mathrm{Frms}^2}{\Delta\,\mathrm{fto}}$$

   Where Frms is the database rms force value and Δfto is the bandwidth of the one-third octave band. Narrow-band database values are to be converted to FSD (f) by the same expression adding the data base rms value only in the single frequency subdivision spanning the data base frequency. The FSD (f) contribution for multiple sources, wideband and narrowband, are to be added to yield a total FSD (f) for each frequency subdivision before Frms is calculated.

The method used for combining results to obtain peak rms for each one-third octave is dependent upon the verification method used. Method A will be used for payloads employing the interface force method and Method B will be used for payloads employing integrated payload and ISS models.

Payload Interface Force Method

Verification of the vibratory requirements shall be by analysis or test. Acceptable methods for performing vibration test are contained in SSP 57010, Appendix E (Microgravity Control Plan).

The following sequence is to be used to verify CIR compliance with paragraph 3.2.6.4.2 k:

1. Obtain disturbance forces in Force Spectral Density (FSD) for each one-third octave.
2. Calculate rms force magnitude within each one-third octave at each payload attachment interface as the RSS of X, Y, and Z components (rms force) in each one-third octave band.

$$\mathrm{Frms} = \left(\sum_{N} H(f)^2 \cdot \mathrm{FSD}(f) \right)^{\frac{1}{2}}$$

   This is to be calculated by combining N frequency subdivisions of each one-third octave per the following equation:

   Where H (f) is the transfer function in lb/lb obtained by the FEM model for each frequency subdivision and FSD (f), is the Force Spectral Density forcing function for each frequency subdivision. The appropriate analytical model shall include the effects of the integrated payload rack and its attachments using a Payload Project Office provided interface model.

3. Find the combined force from all payload attachment interfaces as the RSS of all interface point forces (the results of A above) summed over each one-third octave bands.
4. Compare the combined force with the force limits in Figure 15. The wide-band limit may be used if the peak/average ratio is less than 5, otherwise the narrow-band peak limit must be used.

Verification is successful when the analysis or test results show that the interface forces are less than the limits specified in paragraph 3.2.6.4.2 k..

Adjacent ARIS Payload Acceleration Method

Verification by this technique requires that CIR determine the ARIS interface accelerations resulting from the worst case combination of payload disturbance sources. This method is applicable for CIR. Application of this method requires integration of an ISS Payload Office provided interface model with payload developer FEM and/or SEA models. Verification of ARIS accelerations is to be performed by the following steps:

1. Obtain disturbance forces in Force Spectral Density (FSD) for each one-third octave.
2. Calculate rms acceleration magnitude within each one-third octave at each payload attachment interface as the RSS of X, Y, and Z components (rms acceleration) in each one-third octave band. This is to be performed using unit forces applied in the X,Y, and Z direction separately. The X, Y, and Z components for each direction as a transfer function are to be calculated for all frequencies of interest. The FSD is to be applied to each transfer function yielding force magnitude (RSS of the real and imaginary component) and the RSS of the acceleration magnitude is to be calculated for each 1/3rd octave by combining N frequency subdivisions of each one-third octave per the following equation:

$$\mathrm{Arms} = \left(\sum_{N} H(f)^2 \cdot \mathrm{FSD}(f) \right)^{\frac{1}{2}}$$

   Where H (f) is the transfer function in μg/lb obtained by the FEM model for each frequency subdivision and FSD (f), is the Force Spectral Density forcing function for each frequency subdivision.

3. Find the combined acceleration from all payload attachment interfaces as the RSS of all interface point accelerations (the results of A above) summed over each one-third octave bands.

If the source direction is unknown then the largest response envelope resulting from applying the magnitude in each axis is to be determined. Verification will be considered successful if the rms Average of accelerations at the ARIS interface points from all sources, at all interface points, and all axis does not exceed the limits defined in Table X.

The following equation describes this summation process:

$$\mathrm{Asum} = \left[\frac{\sum_{\mathrm{Np}} \sum_{(X,Y,Z)} \sum_{\mathrm{Ns}} \mathrm{Amag}^2}{\mathrm{Np}} \right]^{0.5}$$

Where:
Amag is the X, Y, or Z magnitude of model output acceleration at each interface point

Ns is the number of sources
Np is the number of ARIS interface points
Asum is the rms acceleration to be compared with Table X for each one-third octave.

l. Verification of maximum transient impulse shall be by analysis or test. Acceptable test methods are defined in SSP 57010, Appendix E. Verification shall be considered successful when the impulse delivered by an integrated rack or non-rack payload over any 10 second period is shown to be less than 10 lb s (44 N s) and when the sum of the impulse and vibration resulting from the impulse do not exceed the vibratory limits of paragraph 3.2.6.4.2 k over any 100 second period. FEM time domain analysis is an acceptable verification method for this requirement as defined in 4.2.6.4.2k. Acceleration or force response test data is acceptable if interface impedance considerations are included, including adjustment for possible modal frequency shift and interface structural amplification or attenuation.

m. The maximum force at the integrated rack or non-rack payload interface, as determined by either analysis or test, shall be less than 1000 lb (4448 N) in any direction. Rigid body analysis may be used if it can be shown that the rigid payload force to a rigid interface will not exceed 500 lb (2224 N). Otherwise, FEM payload analysis using a Payload Project Office supplied ISS model must be used to show that the flexible interface force will not exceed 1000 lb (4448 N).

n. The general verification requirements of 4.2.6.4.2k are applicable. Rigid body assumptions may be made if disturbance frequencies are below the first rack mode. Under baseline ARIS control parameters as used for ISS Stage 5A, the on-board to off-board limits of Figure 17 are most restrictive at low frequencies and the sensor saturation limits are most restrictive at high frequencies. Allowing for the middle frequency range which may affect either requirement, the on-board to off-board analysis may be limited to the low frequency range below 15 and the sensor saturation verification range may be limited to frequencies above 2 Hz. Consequently, based upon assumed payload use of the standard ARIS control parameters, verification may be simplified to meeting the following processes:

Rigid Body Analysis Method

Assuming that the first free-free ARIS mode is greater than 17 Hz, rigid body analysis is sufficient using payload mass properties and known disturbance forces. Effective ARIS interface force shall be calculated by the following method:

1. Obtain frequency domain representations of all input forces by direction and one-third octave. This is to include both narrow-band sources and wide-band sources and the 100 second rms frequency domain representation of transients.
2. Obtain the effective forces due to moments by dividing each moment by the characteristic distance for the moment direction. The characteristic distances are 3 ft (0.91 m) for moments about the rack X and Y axis, and 1.50 ft (0.46 m) for moments about the rack Z axis.
3. The forces and effective forces are to be summed by RSS in the frequency domain of force and effective force by axis.
4. The results are to be summed by RSS of the contribution along each axis in the frequency domain.

5. Compare the results against the allowable limits of Table XII. The wide-band limit may be used if the peak/average ratio is less than 5, otherwise the narrow-band peak limit must be used.

FEM Analysis Method

If the ARIS payload has modes below 17 Hz under operational free-free conditions then FEM analysis will be required. FEM analysis shall be performed using the following method:

1. Obtain frequency domain representations of all input forces by direction and one-third octave. This is to include narrow-band sources, wide-band sources and the 100 second rms frequency domain representation of transients. If rms input vs. frequency data is used, this is to be converted to Frequency Spectral Density (FSD) by guideline 6 of 4.3.1.2.2.
2. Determine the acceleration response at each ARIS actuator interface point and at the center of the umbilical panel.
3. The accelerations are to be summed for each one-third octave as the RSS of all frequencies within each one-third octave by the following equation:

$$\text{Arms} = \left[\sum_{(x,y,z)} \sum_{N} A(d,n)^2 \right]^{\frac{1}{2}}$$

Where A (d, n) is the acceleration by direction (d) and interface point (n).

j. Compare the results against the allowable limits of Table XII The wide-band limit may be used if the peak/average ratio is less than 5. Otherwise the narrow-band peak limit must be used.

4.2.6.4.3 Electrical requirements.

4.2.6.4.3.1 Steady-state voltage characteristics.

The CIR at Interface B steady-state voltage requirements shall be verified by test. Verification of compatibility with steady-state voltage limits shall be performed by test at low and high input voltage values of 116 to 126 Vdc. The EPCE shall be operated under selected loading conditions that envelope the operational loading. The verification shall be considered successful when the test shows under low and high voltage conditions the EPCE is compatible with the steady-state voltage limits of 116 to 126 Vdc. Verification may be performed by the PRCU or equivalent.

4.2.6.4.3.2 Ripple voltage characteristics.

a. Ripple voltage and noise requirements shall be verified by analysis. The verification shall be considered successful when the CS–01 test shows the CIR connected to Interface B and EPCE operate and are compatible with the EPS time domain ripple voltage and noise level of at least 2.5 Vrms within the frequency range of 30 Hz to 10 kHz.

b. Ripple voltage spectrum requirements shall be verified by analysis. Verification shall be considered successful when analysis of the CS–01 and CS–02 test data shows the CIR connected to Interface B and EPCE operates and is compatible with the ripple voltage spectrum in Figure 18.

4.2.6.4.3.3 Transient voltages.

Transient voltage requirements shall be verified by test or analysis. Input voltage shall be 116 Vdc and 126 Vdc with the Interface B source impedance, as specified in SSP 30482 Volume I. Verification of compatibility with the specified transient voltages shall be performed by test or analysis of CIR operation across the transient envelope as specified in Figure 19 of this document. The verification shall be considered successful when the test or analysis shows the CIR is compatible with the EPS transient voltage characteristics as specified in Figure 19.

4.2.6.4.3.4 Fault clearing and protection.

Fault clearing and protection shall be verified by analysis. The verification shall be considered successful when analysis shows the CIR at Interface B does not produce an unsafe condition or one that could result in damage to ISS equipment or payload hardware from the EPS transient voltages as specified in Figure 20.

4.2.6.4.3.5 Non-normal voltage range.

Verification of compatibility with non-normal voltage range conditions shall be performed by analysis. The analysis shall ensure the CIR or EPCE will not produce an unsafe condition or one that could result in damage to ISS equipment external to the CIR or EPCE when parameters are non-normal voltage characteristics of a maximum overvoltage of + 165 Vdc for 10 s and undervoltage conditions of +102 Vdc for an indefinite period of time. The analysis should be performed with all converters directly downstream of Interface B. The verification shall be considered successful when analysis shows the CIR or EPCE is safe within ISS interface conditions.

4.2.6.4.3.6 Power bus isolation.

a. Verification of power bus isolation between two independent ISS Power Buses as specified shall be performed by analysis. The verification shall be considered successful when the analysis shows the CIR, with a source voltage of + 126 Vdc, and its internal and external EPCE provides a minimum of 1-MΩ isolation in parallel with not more than 0.03 μF of mutual capacitance between the two independent power buses including both the supply and return lines.
b. Verification of power bus isolation without the use of diodes shall be verified by analysis. The analysis shall show the exclusion of diodes used to isolate the two independent ISS power bus high side or return lines. The verification shall be considered successful when analysis shows there are no diodes used, to electrically tie together independent ISS power bus high side or return lines, within the CIR and its internal and external EPCE.

4.2.6.4.3.7 Compatibility with soft start/stop remote power controller (RPC).

Compatibility with soft start/stop RPC(s) shall be verified by test. Verification of initialization with soft start/stop performance characteristics shall be performed by test when the initial supply of power is provided to the equipment connected to the RPC(s). Input power to the payload EPCE shall be delivered though a PRCU or equivalent. The EPCE connected to Interface B shall be operated with multiple load combinations at levels ranging from 0 to 100% of the RPC rated conductivity. The verification shall be considered successful when test shows the EPCE can initialize operation and prove compatibility with the soft start/stop RPC characteristics, representative of Figure 21.

4.2.6.4.3.8 Surge current.

Surge current shall be verified by test and analysis. Input power to the CIR or EPCE should be representative of the ISS power environment. Verification of compatibility with surge current limits shall be performed by test at high, nominal, and low input voltage values as specified. The power source used to perform the test shall be capable of providing a range of power between 0 to 6 kW at 116–126 Vdc for Interface B connected equipment. The EPCE shall be operated under selected loading conditions that envelope the operational loading. The analysis shall be performed using test data from the above test. The analysis shall indicate operability and compatibility exist based on test data and the requirements specified in paragraph 3.2.6.4.3.8. The verification shall be considered successful when test and analysis shows under high, nominal, and low voltage conditions the EPCE can perform all functional capabilities and prove compatibility by operating within the specified limits of paragraph 3.2.6.4.3.8.

4.2.6.4.3.9 Reverse energy/current.

Reverse energy/current shall be verified by analysis. Input power to the CIR or EPCE should be representative of the ISS power environment. Verification of compatibility with reverse energy/current limits shall be performed by analysis at 6 kW, 3 kW, or 1.44 kW values corresponding to the CIR or EPCE design. The power source used to perform the analysis shall be capable of providing a range of power between 0 and 6 kW at 116–126 Vdc for Interface B connected equipment. The EPCE shall be analyzed under selected loading conditions that envelope the operational loading. The verification shall be considered successful when analysis shows that the CIR or EPCE complies with requirements defined in Table XIII for the reverse energy/current into the upstream power source. Also, when the reverse energy or the reverse current requirement for all environmental conditions specified in this document when powered from a voltage source with characteristics specified in SSP 57000, paragraphs 3.2.1 and 3.2.2.4 when a source impedance of 0.1 Ω is met.

4.2.6.4.3.10 Current protection devices.

a. Tests shall be performed to show the CIR connected to an Interface B ISPR location operates and is compatible with the characteristics shown and described in SSP 57001, paragraph 3.2.6, Figures 3.2.6–1, 3.2.6–2, and 3.2.6–3. The tests shall be performed at initiation of power to the CIR and with multiple internal load combinations that include, but are not limited to sub-rack payloads. The verification shall be considered successful if the test results show the initial current flow, when powered “on,” to the CIR and current flow during the CIR operations with multiple internal load combinations including sub-rack payloads does not exceed the current magnitude and duration as defined and described in SSP 57001, paragraph 3.2.6, Figures 3.2.6-1, 3.2.6-2, and 3.2.6-3.

b. Analysis of electrical circuit schematics shall be performed to show overcurrent protection exists at all points in the payload electrical architecture system where power is distributed to lower level (wire size not protected by upstream circuit protection device) feeder and branch lines. The analysis shall be considered successful when results show overcurrent protection exists at each point in the payload electrical architecture system where power is distributed to lower level (wire size) feeder and branch lines.

c. Analysis of electrical circuit schematics shall be performed to show current limiting overcurrent protection exists for all internal loads drawing power from an Interface B power feed(s). The analysis shall be considered successful when results show current limiting overcurrent protection exists in the distribution paths to all load devices connected to an Interface B power feed(s).

4.2.6.4.3.11 CIR trip ratings.

The CIR trip ratings shall be verified by test and demonstration. Input power to the integrated rack or EPCE should be representative of the ISS power environment. The test and demonstration shall be performed as specified in paragraph 4.2.6.4.3.10. The verification shall be considered successful when test and demonstration shows the requirements specified in paragraph 4.2.6.4.3.10 are met.

4.2.6.4.3.12 Interface B complex load impedances.

The following verification requirements apply to subparagraphs 3.2.6.4.3.12 a and b. CIR complex load impedance(s) shall be verified by test. Verification may be performed by the PRCU or equivalent only if the PRCU or equivalent meets SSP 30482 Volume 1, Rev. C source impedance requirements. All active converters directly downstream of Interface B shall be qualification or flight hardware. Loading of the downstream converter(s) can be simulated to provide full range of active converter loading. Load impedance shall be tested under conditions of high, nominal, and low voltage to the CIR and with these conditions for the active converters directly downstream shall be exercised through the complete range of their loading. Selected combinations of converters that can influence the measured load impedance at Interface B shall be tested. The verification shall be considered successful when the test shows that all load impedances measured for high, nominal, and low voltage conditions remain within specified limits.

4.2.6.4.3.13 Large signal stability.

Large signal stability shall be verified by test and analysis. A large signal stability test shall be conducted for the integrated rack connected to Interface B. An integrated analysis shall be provided by the CIR integrator for representative maximum and minimum case loads to demonstrate that impedance variations will not impact system stability. The input and transient response waveform for the CIR and EPCE shall be recorded from the start of the pulse through the time when the transient diminishes to and remains below 10% of the maximum amplitude of the response.

The required test conditions may be produced using a programmable power source or the setup shown in Figure 46. The 25 amp and 50 amp LISN or equivalent is to be used for integrated racks connecting to Interface B and the 12 amp LISN or equivalent is to be used for EPCE connecting to Interface C as shown in Figure 47. The pulse generator/amplifier must provide a source impedance of less than 0.2 Ω from 100 Hz to 10 kHz to the 2 Ω load of the primary side of the pulse transformer. Pulses of 100, 125, and 150 μs (±10 μs) duration shall be applied. The pulse amplitude at the secondary side of the injection transformer should be between 10 and 15 V. Pulse rise and fall times must not exceed 10 μs between 10 and 90% of the pulse amplitude. The resulting transient responses must remain within the EPS normal transient limits.

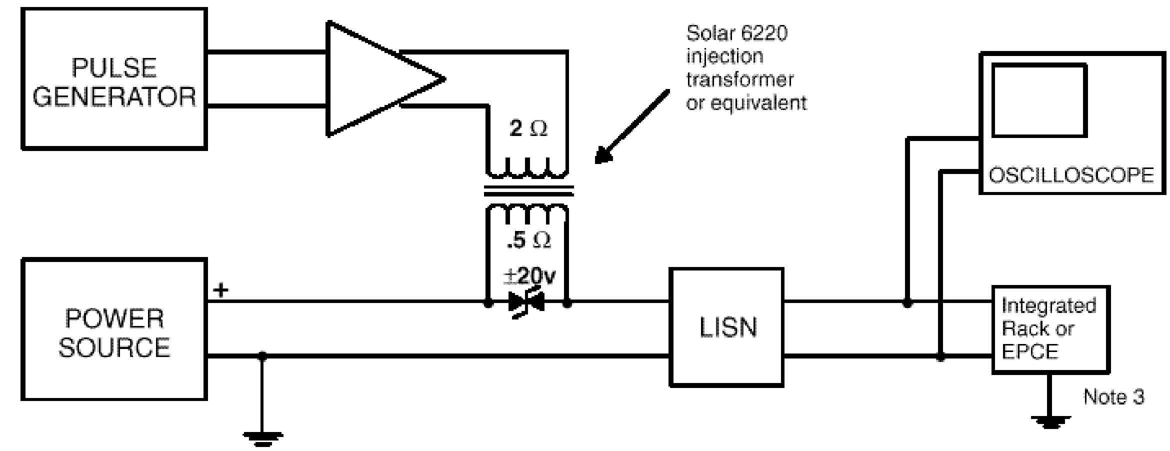
The test and analysis shall be considered successful when results show transient responses, measured at the input to CIR or EPCE, diminish to 10% of the maximum amplitude within 1.0 ms and remain below 10% thereafter.

4.2.6.4.3.14 Maximum ripple voltage emissions.

Maximum ripple voltage emissions shall be verified by test and analysis. Maximum ripple voltage induced on each of the power lines by the CIR and EPCE connected to Interface B shall be verified by test using the CE–07 test configuration of SSP 30238 (measured with a 20 MHz bandwidth instrument). Maximum ripple voltage for the on-orbit configuration of the CIR shall be verified by analysis of test data from individual EPCE test results. The verification shall be considered successful when:

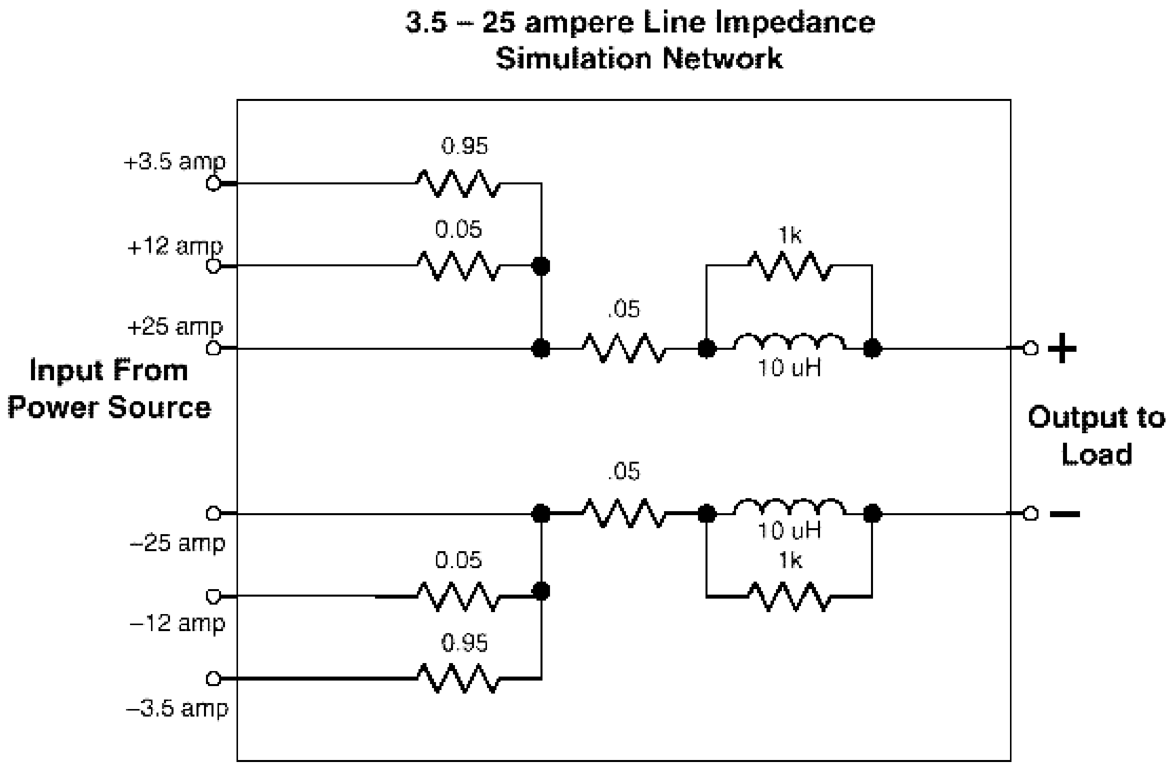
1. Test shows the CIR and EPCE does not induce voltage levels, at or upstream of Interface B, greater than 0.5 V peak-to-peak from supply to return line.
2. Analysis of test data shows the on-orbit configuration of the CIR does not induce voltage levels at or upstream of Interface B, greater than 0.5 V peak-to-peak from supply to return line.

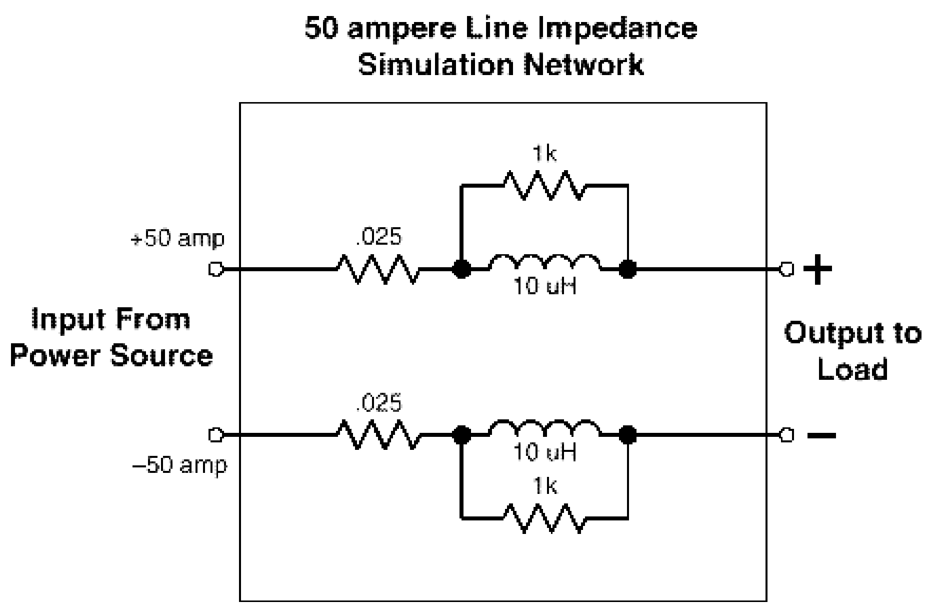
Note: Measurement of transients, as defined in SSP 30237 CE–07, is not required in this test procedure.



NOTES:
1. The output of the pulse generator must be applied to the transformer through a drive amplifier capable of providing an output impedance of 0.2 ohms, or less, from 100 Hz to 10 kHz.
2. The drive amplifier should be capable of delivering at least 75 watts rms into a 4 Ohm load and be suitable for EMC CS–01 tests.
3. Chassis of integrated rack must be grounded; portable equipment is not grounded.
4. Pulse generator, injection transformer and Zener diode may require adjustment to generate the test pulses and to protect the integrated rack or EPCE under test.

Figure 46. Stability test setup, transient responses





Note: Resistance is in Ohms

Figure 47. ISS line impedance simulation network (LISN)

4.2.6.4.3.15 Wire derating.

a. Wire derating for the EPCE at and downstream of the primary circuit protection device(s) in the CIR shall be verified by analysis. Analysis of the electrical power schematics shall be performed to show that the wire gauge of the CIR and EPCE meets the requirements as specified in Figure 28. The verification shall be considered successful when the analysis shows the CIR and EPCE meet the wire derating requirements as specified in NASA Technical Memo (TM) 102179 as interpreted by NSTS 18798, TA–92–038. Wire gauge meeting the requirements of SSP 30312 is accepted as meeting the requirements of NASA Technical Memo (TM) 102179 as interpreted by NSTS 18798, TA–92–038.
b. Wire size for the wire/cable from UIP to the primary circuit protection device(s) in the CIR shall be verified by inspection or analysis. Inspection or analysis of cable drawings shall be performed to show that the wire gauge uses 4 gauge wire for main and auxiliary connections at the UIP. The verification shall be considered successful when the inspection or analysis shows that 4 gauge wires are used for main and auxiliary connections from UIP to the primary circuit protection device(s) in the CIR.

4.2.6.4.3.16 Exclusive power feeds.

The exclusive power feeds requirement shall be verified by analysis of electrical circuit schematics. The analysis shall be considered successful when the electrical schematics show:

a. The CIR only receives power from the UIP dedicated to its rack location.
b. Cabling does not occur between Interface C connected EPCE with Interface B; and/or Interface B connected EPCE with Interface C.

4.2.6.4.3.17 Loss of power.

Verification that the equipment connected to Interface B meets the loss of power safety requirements specified in NSTS 1700.7, ISS Addendum shall be verified by test and submitted to the Payload Safety Review Panel (PSRP) in accordance with NSTS 13830. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.

4.2.6.4.3.18 Electromagnetic compatibility.

The electromagnetic compatibility (EMC) of the CIR EPCE shall be verified by test, analysis, and/or inspection. The test shall be considered successful when the results show that the CIR EMC is in compliance with the requirements of SSP 30243, paragraphs 3.1, 3.5, and 3.6.2. The analysis shall be based on end item qualification data and CIR EPCE design and analysis data. The analysis shall be considered successful when the data shows the CIR EPCE meets the EMC requirements of SSP 30243, paragraphs 3.1, 3.5, and 3.6.2. The inspection shall be based on physical/visual indications of the CIR EPCE. The inspection shall be considered successful when physical/visual indications show the EMC requirements of SSP 30243, paragraph 3.1, 3.5, and

3.6.2 are met. The requirements of SSP 30243, paragraphs 3.1 and 3.6.2 shall be verified by test and analysis. The test shall be considered successful when results show the CIR connected to Interface B meets the requirements specified in SSP 30243, paragraph 3.6.2. The results of the EMC test shall be documented in the EMC test plan/report. The analysis shall be documented in an EMC Control Plan and Design Analysis Report. The analysis shall include determining the necessary requirements for equipment not connected directly to Interface B such that the entire payload meets the EMC requirements of SSP 57000. The analysis shall be considered successful when results show that the requirements defined in paragraph 3.1 of SSP 30243 have been met.

Note:

1. The Control Plan and the Design Analysis Report can be combined into one document per payload provider format.
   k. Clarifications to SSP 30243, paragraph 3.6.2:
   a. Only the impedance characteristics of the power source need to be simulated.
   b. Only representative simulated signals and loads for the interface tests are required.
   c. Verification of the on-orbit configuration of the integrated rack may be performed analytically if and only if the on-orbit configuration differs from the Qualification Test configuration.
   l. Details of the EMC Control Plan, Design Analysis Report, and EMC Test Plan/Report are located in SSP 57010.
   m. If analysis shows requirements of paragraph 3.6.2 of SSP 30243 are met during CIR or multiple EPCE EMI testing, as defined SSP 30237, a separate EMC test plan/report is not needed.

4.2.6.4.3.18.1 Electrical grounding.

The electrical grounding of the CIR EPCE shall be verified by test and analysis. The test shall be considered successful when the results show that CIR grounding is in compliance with the requirements in section 3 of SSP 30240. The analysis shall be based on end item qualification data and CIR EPCE design and analysis data. The analysis shall be considered successful when the data shows the CIR EPCE is electrically grounded within the requirements of section 3 of SSP 30240.

4.2.6.4.3.18.2 Electrical bonding.

The electrical bonding of the CIR EPCE shall be verified by test, analysis, and inspection. The test shall be considered successful when the results show all requirements of SSP 30245 and the requirements of NSTS 1700.7, ISS Addendum in sections 213 and 220 are met. The analysis shall be based on end item qualification data and CIR EPCE design and analysis data. The analysis shall be considered successful when the data shows the CIR EPCE is electrically bonded within the requirements of SSP 30245 and the requirements of NSTS 1700.7, ISS Addendum in sections 213 and 220 are met. The inspection shall be based on physical/visual indications of the CIR EPCE. The inspection shall be considered successful when physical/visual indications show all requirements of SSP 30245 and the requirements of NSTS 1700.7, ISS Addendum in sections 213 and 220 are met.

4.2.6.4.3.18.3 Cable/wire design and control requirements.

The cable and wire design of the CIR EPCE external cables shall be verified by test, analysis, or inspection. The test shall be considered successful when the results show all requirements of SSP 30242 are met. The analysis shall be based on CIR EPCE design and analysis data. The analysis shall be considered successful when the results show all requirements of SSP 30242 are met. The inspection shall be based on physical/visual indications of the CIR EPCE. The inspection shall be considered successful when physical/visual indications show that external cable and wire design is in compliance with the requirements of SSP 30242. SSP 30242 harness requirements can normally be met by inspection of drawings and hardware. Analysis is required to classify signals and determine the necessary isolation between signals. Test may be required to determine impedance and sensitivity characteristics of the circuit when classification cannot be determined by examination of the circuit known characteristics.

4.2.6.4.3.18.4 Electromagnetic interference.

The electromagnetic interference of the CIR EPCE shall be verified by test and analysis. Tests shall be performed and data submitted for conducted susceptibility and radiated susceptibility, in addition to that for conducted emissions and radiated emissions. This data shall be evaluated against the limits of SSP 30237. The test results shall be documented in the EMI test plan/report. The test shall be considered successful when the results show requirements of SSP 30237 are met.

Note: EMI test plan/report details are located in SSP 57010.

The analysis of the CIR shall be performed using CIR assembly equipment test data as mentioned in the above paragraph. The analysis shall be considered successful when the results show requirements of SSP 30237 are met. This analysis includes evaluating the degree of isolation from 30 Hz to 400 MHz provided by the EPCE for power ripple and transients to the equipment using isolated power. An analysis of the isolation in conjunction with the equipment conducted requirements should be submitted in the EMC Control Plan to verify the requirements of SSP 57000 are met. The EMI test methods shall be as specified in SSP 30238.

4.2.6.4.3.18.5 Electrostatic discharge.

The susceptibility of the electrostatic discharge (ESD) of the unpowered CIR EPCE and its components shall be verified by test or analysis and inspection. The analysis shall be based on CIR EPCE design and analysis data. The test or analysis shall be considered successful when the results show the unpowered CIR and its components shall not be damaged by ESD equal to or less than 4,000 V to the case or any pin on external connectors. EPCE that may be damaged by ESD between 4,000 and 15,000 V shall have a label affixed to the case in a location clearly visible in the installed position. The inspection shall be based on physical/visual indication of the payload EPCE.

4.2.6.4.3.18.6 Alternating current (ac) magnetic fields.

The ac magnetic fields requirement for the CIR connected to Interface B, including cables and interconnecting wiring, shall be verified by test. The test shall be performed using the MIL-STD-462D RE01 Method with the following modifications:

1. Test setup guidelines shall be per SSP 30238, Figure 3–9 or 3–10, not the setup identified by MIL–STD–462D.
2. Guidelines of SSP 30238, Figures 3–9 and 3–10, requirement of 1 m separation does not apply to RE01.
3. Measurements are required from 30 Hz to 50 kHz rather than 100 kHz required by MIL–STD–461D.
4. Measurements are performed at 7 cm from the generating equipment. In the event emissions are out-of-specification, measurements are performed at 50 cm from the generating equipment.
5. Emissions greater than 20 dB below the specified limits shall be recorded in the EMI test report. In cases where the noise floor and ambient are not 20 dB below specified level, only those emissions above the noise floor/ambient are required to be recorded.

The verification shall be considered successful when test results show the generated ac magnetic fields of the CIR connected to Interface B, including cables and interconnecting wiring, do not exceed 140 dB above 1 pT between 30 Hz to 2 kHz, and the fall off is no less than 40 dB per decade to 50 kHz.

4.2.6.4.3.18.7 Direct current (dc) magnetic fields.

The dc magnetic fields requirement for the CIR connected to Interface B with electromagnetic and/or permanent magnetic devices shall be verified by test or analysis. The measurement or analysis of dc magnetic fields shall be performed at 7 cm from the generating equipment. For integrated racks and EPCE that exceed the design requirement, measurements or analysis at 10 cm from the generating equipment shall be performed if there is a dc magnetic field greater than 170 dB above 1 pT. Additional measurements or analyses shall be performed at 10 cm increments away from the generating equipment until data proves the dc magnetic fields are 6 dB below the 170 dB above 1 pT requirement. The verification shall be considered successful when test or analysis results show the generated dc magnetic fields of the CIR connected to Interface B do not exceed 170 dB above 1 pT at a distance of 7 cm from the generating equipment, including electromagnetic and permanent magnetic devices.

4.2.6.4.3.18.8 Corona.

Equipment with voltages (steady-state, transient, internal, or external) greater than 190 V or equipment containing gases mixture other than those present in the pressurized module shall be verified by analysis or test to the degree necessary to ensure no permanent damaging effects and no hazardous conditions due to destructive corona will exist in its operating environment. The operating environment is defined as normal pressurized atmosphere as specified in Table IV or depressurized module if the payload is still powered. If the equipment (with voltages greater than 190 V) may be powered during depressurization, the verification shall be by test.

4.2.6.4.3.18.9 Lightning.

The lightning requirement shall be verified by analysis. The analysis shall be considered successful when the data shows that the CIR and EPCE is compatible with the requirements specified in SSP 30243, paragraph 3.2.8.1. Note: The analysis data should be based on end item qualification design data and analysis data of the CIR or EPCE.

4.2.6.4.3.18.10 EMI susceptibility for safety-critical circuits.

Safety critical circuits should be verified by test and analysis. The analysis shall be considered successful when the results show the requirements of SSP 30243, paragraph 3.2.3 are met.

4.2.7 Transportability.

The CIR transportability within the United States without damage by truck or air via common commercial carrier when packaged as specified herein without requiring special accommodation to meet the transportation and handling limit load factors as specified in Table XIV shall be verified by analysis. The verification shall be considered successful when the analysis shows that the transportation and handling limit load factors as specified in Table XIV are met.

4.2.7.1 CIR launch and return.

The CIR design, in its launch configuration, and the stowed CIR hardware design to withstand a minimum of two shuttle launches and landings in the MPLM shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR, in its launch configuration, and the stowed CIR hardware are designed to withstand a minimum of two shuttle launches and landings in the MPLM.

4.3 Design and construction.

4.3.1 Materials, processes, and parts.

4.3.1.1 CIR specific material requirements.

4.3.1.1.1 Materials – general.

Verification that parts and materials meet the requirements of paragraphs 208.3 and 209 of NSTS 1700.7 and NSTS 1700.7, ISS Addendum shall be verified by inspection as specified in FCF-PLN-0036. Verification shall be considered successful when GRC accepts all materials per the requirements of FCF-PLN-0036.

4.3.1.1.2 ITCS Fluids.

a. Verification of fluid physical and chemical characteristics shall be by test. A test shall be conducted according to the verification test requirements specified in SSP 30573, section 4.0

to determine whether or not the fluid contained in the CIR interfacing with the ISS satisfies the fluid physical and chemical characteristics. The verification shall be considered successful if the test results show the CIR fluid physical and chemical characteristics meet the fluid chemistry requirements in SSP 30573.

b. Verification of fluid system cleanliness levels shall be by test. The verification shall be considered successful when samples per SSP 30573, section 4.0 show that fluids in the CIR comply with the cleanliness level requirements specified.
c. Verification of fluid system dissimilar metals compatibility shall be by inspection or analysis. The inspection shall compare the materials and parts list with the materials listed in MSFC-SPEC-250, Table III. Verification success shall be when the inspection of the materials and parts list show the internal materials used in the CIR aqueous fluid systems are compatible according to the table specified. Analysis shall be performed on materials not listed in MSFC-SPEC-250, Table III. Verification success shall be when the analysis of the materials show the internal materials used in the CIR aqueous fluid systems do not create a dissimilar metal couple greater than 0.25 V with the ISS aqueous fluid system.

4.3.1.1.3 Connectors.

Connectors used in the CIR, external to the assembly level, consisting of MIL-C-38999, MIL-C-5015, MIL-C-81569, MIL-C-83733, or SSQ 21635 as specified in SSP 30243, Figure 4.1-8, shall be verified by inspection. The verification shall be considered successful when the inspection shows the connectors used in the CIR, external to the assembly level, consist of MIL-C-38999, MIL-C-5015, MIL-C-81569, MIL-C-83733, or SSQ 21635 as specified in SSP 30423, Figure 4.1-8.

4.3.1.1.4 External cleanliness.

a. Verification that the CIR conforms prior to launch to VC-S cleanliness requirements as specified in SN-C-0005 shall be by inspection. An inspection of the cleanliness documentation required by precision cleaning shall be performed to show that each part, component, subsystem, and system of the end product meets the VC-S requirement. Verification shall be considered successful when the inspection shows that each part, component, subsystem, and system of the end product meets prior to launch the VC-S requirement.
b. Verification that the CIR external surfaces, with applicable PI hardware, meet the minimum acceptable cleanliness environment as measured by the US Lab shall be by inspection. The verification is considered successful when the inspection shows the CIR external surfaces, with applicable PI hardware, meet the minimum acceptable cleanliness environment as measured by the US Lab.

4.3.1.2 Toxic products and formulations.

The CIR toxic product and formulation requirements as specified in FCF-PLN-0036 shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR toxic product and formulation requirements as specified in FCF-PLN-0036 are met.

4.3.1.3 Volatile organic compounds.

The CIR volatile organic compound requirements as specified in FCF-PLN-0036 shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR volatile organic compound requirements as specified in FCF-PLN-0036 are met.

4.3.1.4 Hazardous materials.

The CIR hazardous material requirements as specified in FCF-PLN-0036 shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR hazardous material requirements as specified in FCF-PLN-0036 are met.

4.3.1.5 Protective coatings.

The CIR protective coating requirements as specified in FCF-PLN-0036 shall be verified by inspection. The verification is considered successful when the inspection shows the CIR protective coating requirements as specified in FCF-PLN-0036 are met.

4.3.2 Electromagnetic radiation.

4.3.2.1 Ionizing radiation.

Not applicable.

4.3.2.2 Nonionizing radiation.

Not applicable.

4.3.2.3 Operating environment.

Not applicable.

4.3.2.4 Generated environment.

Not applicable.

4.3.3 Nameplates and product marking.

4.3.3.1 Nameplates.

4.3.3.2 CIR identification and marking.

Labels on the CIR, all sub-rack elements (installed in the rack or separately), loose equipment, stowage trays, consumables, assemblies, crew accessible connectors and cables, switches, indicators, and controls shall be verified by inspection. The inspection shall be of the FCSD approval documentation. The verification shall be considered successful when the CIR, all sub-rack elements (installed in the rack or separately), loose equipment, stowage trays, consumables, assemblies, crew accessible connectors and cables, switches, indicators, and controls have been shown to have FCSD approved labels. The instructions for FCSD to follow in granting approval of labels are located in SSP 57000 Appendix C.

4.3.3.2.1 CIR component identification and marking.

All CIR parts legibly and permanently marked with a PIN shall be verified by inspection. The following exceptions shall apply to CIR component identification and marking:

a. Commercial-Off-the-Shelf (COTS) items marked with visible, permanent, and commercial identification.
b. Parts within a COTS assembly that are not subject to removal, replacement, or repair.
c. Parts within an assembly that are permanently installed and are not subject to removal, replacement, or repair.
d. Parts that cannot be physically marked or tagged due to lack of space or when marking would have a deleterious effect shall be temporarily tagged or packaged until the part is installed on the next higher assembly.

The verification shall be considered successful when the inspection shows all CIR parts legibly and permanently marked with a PIN, excluding the exceptions listed above.

4.3.3.2.2 CIR lighting design.

a. Verification of the specularity of the total work surface reflection shall be by test or inspection. The test shall be considered successful when the specularity of the total work surface reflection does not exceed 20%. The inspection shall be considered successful if the work space surface uses paint(s) selected from Table XV. If other work surface coatings are used, the test shall be considered successful if the measured specularity of the work surface does not exceed 20%.
b. The task illumination level identified in Table XVI shall be verified by test. The test shall be considered successful when illumination levels measured at the task site(s) meet those identified in Table XVI.
c. The use of the PUL for medium CIR operational tasks shall be verified by analysis or test. The analysis or test shall show the PUL placed in a configuration that provides the required level of illumination at the task site. The analysis or test shall be considered successful when it shows that the CIR is designed to use the PUL for all medium CIR operational tasks.
d. All text on surfaces intended to be read by the on-orbit crew being black lusterless, 37038 as specified in FED-STD-595, on off-white, semi-gloss, 27722 background as specified in FED-STD-595 shall be verified by inspection. The verification shall be considered successful when the inspection shows all text on surfaces intended to be read by the on-orbit crew is black lusterless, 37038 as specified in FED-STD-595, on off-white, semi-gloss, 27722 background as specified in FED-STD-595.
e. Verification of all aluminum surfaces susceptible to wear being clear or black hard coat anodized or equivalent shall be verified by inspection. The verification shall be considered

successful when the inspection shows all aluminum surfaces susceptible to wear are clear or black hard coat anodized or equivalent.

f. CIR components exempt from the lighting design requirement if the surfaces are color coded to meet other requirements as specified herein, such as interior component surfaces, COTS components, fluid system tubing, and surfaces required by science or safety to exhibit specific characteristics shall be verified by inspection. The verification shall be considered successful when the inspection shows all exempted components meet the exemption requirements specified herein.

4.3.3.2.3 Touch temperature warning labels.

Warning labels provided at the surface site of any CIR component that exceeds a temperature of 49°C (120°F), including surfaces not normally exposed to the cabin, in accordance with the NASA IVA Touch Temperature Safety interpretation letter JSC, MA2-95-048 shall be verified by analysis and inspection. The analysis verification shall be considered successful when the analysis shows the locations where warning labels are required. The inspection verification shall be considered successful when the inspection shows the warning labels provided at the identified surface site.

4.3.3.2.4 Connector coding and labeling.

a. The coding of both halves of CIR mating connectors shall be verified by inspection. Verification shall be considered successful when an inspection shows that both halves of mating connectors display a code or identifier which is unique to that connection.
b. Connector coding and labeling shall be verified by inspection. Verification shall be considered successful when an inspection shows that labels or codes on connectors are visible when connected or disconnected.
c. Pin identification shall be verified by inspection. Verification shall be considered successful when an inspection shows that each pin is uniquely identifiable in each plug and each electrical receptacle with at least every 10th pin labeled.

4.3.3.3 Portable fire extinguisher (PFE) and fire detection indicator labeling.

a. Verification that the PFE access port is labeled with a SDD32100397-002 “Fire Hole Decal” shall be by inspection. Verification shall be considered successful when the inspection shows a SDD32100397-002 “Fire Hole Decal” was placed over the PFE access port.
b. Verification that the CIR Fire Detection Indicator LED is labeled with “SMOKE INDICATION” shall be by inspection. Verification shall be considered successful when the inspection shows the label “SMOKE INDICATION” has been placed above the Fire Detection Indicator LED using lettering per MSFC-STD-275 with 3.96-mm (0.156-in.) letters, style Futura Demibold, and color 37038 (Lusterless Black) per FED-STD-595. The CIR using the ISS provided LED on the Rack Maintenance Switch Assembly (RMSA) with the engraved “SMOKE INDICATION” label shall be considered in compliance with this requirement.

4.3.3.4 Electrostatic discharge sensitive parts labeling.

Verification that all parts sensitive to damage from ESD are properly labeled shall be by inspection based on physical/visual indication of the CIR. The inspection shall be considered successful when physical/visual indications show the labeling of EPCE susceptible to ESD up to 15, 000 V are in accordance with MIL-STD-1686.

4.3.4 Workmanship.

Verification that the CIR, with applicable PI hardware, conforms to the workmanship standards in accordance with NHB 5300.4(1B) shall be by inspection. The verification shall be considered successful when the inspection shows the CIR, with applicable PI hardware, conforms to the workmanship standards in accordance with NHB 5300.4(1B).

4.3.5 Interchangeability.

Verification that all ORU's with the same part number are functionally and dimensionally interchangeable shall be by demonstration. The verification shall be considered successful when the demonstration shows all ORU's with the same part number are functionally and dimensionally interchangeable.

4.3.5.1 On-orbit interchangeability.

Verification that the assemblies and components listed below are interchangeable on-orbit shall be by demonstration. The verification shall be considered successful when the demonstration shows the capability that the assemblies and components listed below are interchangeable on-orbit.

a. IPP
b. IOP
c. EPCU
d. GC Assembly
e. GC Outlet Valve Assembly
f. FCU
g. IOP Disk Drives
h. Exhaust Pump Assembly
i. Exhaust Vent Manifold Assembly
j. Vent Manifold Assembly
k. Exhaust Manifold Assembly
l. MV4 Manifold Assembly
m. Fuel Manifold Assembly
n. Diluent/Pre-Mix Manifold Assembly
o. Static Mixer Assembly
p. High Pressure Oxygen Manifold Assembly
q. Nitrogen/High Pressure Manifold Assembly
r. All Temperature Sensors
s. All Pressure Sensors

t. All Solenoid Valve Coils
u. Bottle Assemblies
v. All Adsorber Cartridge Assemblies
w. All Diagnostic Modules/Packages
x. ATCS Air Filters

4.3.6 Safety.

Verification that the CIR, with applicable hardware and software, meets the applicable requirements as specified in NSTS 1700.7, ISS Addendum shall by analysis, inspection, and test. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.

4.3.6.1 Fire Prevention.

Verification that the CIR meets the fire prevention requirements specified in NSTS 1700.7, ISS Addendum, paragraph 220.10 a. shall by analysis and inspection. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.

4.3.6.1.1 Smoke detector.

a. Verification that the CIR uses a smoke detector that meets the requirements specified in D683-10007 and SSP 30262:013 shall be by inspection. Verification shall be considered successful when the inspection shows the end item spec and Interface Control Document of the smoke detector used meets the requirements specified in D683-10007 and SSP 30262:013 respectively. If the CIR uses the ISS provided smoke detector, the CIR shall be considered in compliance with this requirement.
b. Verification that the CIR provides a smoke detector interface at the J43 connection shall be by inspection and demonstration. The inspection shall consist of reviewing schematics/drawings to verify they show wiring to the J43 connector. The verification shall be considered successful when the inspection shows wiring from the smoke detector to the J43 connector. The demonstration shall be conducted to show the connector mates with the ISS equivalent connector. The verification shall be considered successful when the demonstration shows the connector mates with the ISS equivalent connector.

4.3.6.1.1.1 Maintenance switch, smoke detector, smoke indicator, and CIR fan interfaces.

Verification of the CIR maintenance switch interface shall be by inspection and test. Verification shall be by inspection of the CIR maintenance switch interface to the CIR hardware ICD against and SSP 57001. Verification shall be to test the CIR with the PRCU, for correct operation of the CIR maintenance switch.

4.3.6.1.1.2 Smoke detector analog interface characteristics.

Verification of the analog interface characteristics shall be by inspection. Verification shall be by inspection of the analog interface characteristics to the CIR hardware ICD against and SSP 57001.

4.3.6.1.1.3 Discrete command built-in-test interface characteristics.

Verification of the discrete command BIT interface characteristics shall be by inspection. Verification shall be by inspection of the discrete command BIT interface characteristics to the CIR hardware ICD against and SSP 57001.

4.3.6.1.1.4 Smoke indicator electrical interfaces.

Verification of the smoke indicator electrical interface shall be by inspection and test. Verification shall be by inspection of the discrete command BIT interface characteristics to the CIR hardware ICD against and SSP 57001. Verification shall be to test the CIR with the PRCU, for function of the smoke indicator on P43. No test on the luminance of the indicator is required.

4.3.6.1.1.5 Fan ventilation status electrical interfaces.

Verification of the discrete command BIT interface characteristics shall be by inspection. Verification shall be by inspection of the discrete command BIT interface characteristics to the CIR hardware ICD against and SSP 57001.

4.3.6.1.1.6 Rack maintenance switch (rack power switch)/fire detection support interface connector.

Verification of the CIR Switch/Fire Detection Support Interface (maintenance) Connector shall be by inspection. Verification shall be by inspection of the CIR Maintenance Connector to mate with a Test Connector SSQ 21635, NATC07T13N35SA.

a. No verification required (NVR). Physical mating verification requirements are specified in paragraph 4.2.2.9.1.
b. Verification of P43 appropriate pin assignment shall be by inspection. The inspection shall be an inspection of payload drawings to verify that the P43 pinout matches the corresponding J43 pinout. The verification shall be considered successful when the inspection shows that the P43 connector pinout is appropriate.
c. Verification of the P43 connector with the requirements of SSQ 21635 shall be by inspection. The inspection shall consist of an inspection of the drawings to identify that the SSQ 21635 requirement is identified on the drawing for the P43 connector.

4.3.6.1.2 Fire detection indicator.

a. Verification that the CIR using a smoke detector providing a red Fire Detection Indicator LED in an easily visible location on the front of the rack shall be by test and inspection. The test shall show the LED meets or exceeds the operational characteristics of the ISS provided LED when provided the interface characteristics defined in SSP 57000, paragraph 3.3.10. Test verification shall be considered successful when the test shows the indicator LED meets or exceeds the operational characteristics of the ISS provided LED when provided the interface characteristics defined in SSP 57000, paragraph 3.3.10. The CIR using the ISS provided Fire Detection Indicator LED shall be considered in compliance with this requirement. The inspection shall show the LED is positioned in an obvious, easily viewed location on the aisle side of the CIR. Inspection verification shall be considered successful when the inspection shows the LED is positioned in an obvious, easily viewed location on the aisle side of the CIR.

b. Verification that the CIR provides a fire detection indicator interface at the J43 connection shall be by inspection. The inspection shall consist of reviewing schematics/drawings to verify they show wiring to the J43 connector. The verification shall be considered successful when the inspection shows wiring from the fire detection indicator to the J43 connector.

4.3.6.1.3 Forced air circulation indication.

Verification that the CIR provides a signal or data indicating whether or not air flow is being provided to the smoke detector when the smoke detector is in use shall be by test. Verification shall be considered successful when the test shows signal strength meets the interface characteristics in paragraphs 3.3.6.1.1.1 though 3.3.6.1.1.6 when airflow of 3-30.5 m/s (10–100 ft/s) is provided at the smoke detector.

4.3.6.1.4 Fire parameter monitoring in the CIR.

a. Verification that the CIR provides manual and automatic capability to terminate forced air circulation (if present) and power to the CIR shall be by test. A test with the PRCU or equivalent shall be conducted to determine whether or not forced air circulation and electrical power can be manually or automatically terminated in the CIR when an “out of bounds” condition is indicated by the parameter monitoring sensors. Verification shall be considered successful when the test shows forced air circulation and electrical power can be terminated manually or automatically when an “out of bounds” condition is indicated by the parameter monitoring sensors.
b. Verification that the CIR responds to an “out of bounds” condition by sending data to indicate the occurrence and location of the “out of bounds” condition to the payload MDM in the format specified in paragraph 3.4.1.1.5.4 shall be by test. A test with the PRCU or equivalent shall determine whether or not the CIR health and status data is formatted to indicate the occurrence and location of an “out of bounds” condition when one is indicated by parameter monitoring sensors. Verification shall be considered successful when the test shows data is sent in the format specified in paragraph 3.4.1.1.5.4 to indicate the occurrence and location of an “out of bounds” condition when one is indicated by the parameter monitoring sensors.

4.3.6.1.5 Fire suppression access port accessibility.

a. Verification that CIR provides a PFE access port for each rack volume containing a potential fire source shall be by inspection and analysis. An analysis of the CIR volume design shall be conducted to determine whether or not the CIR volume contains a potential fire source. If there is a potential fire source present, an inspection shall be conducted to determine whether or not an access port with a diameter between 12.7 mm (0.5 in.) and 25.4 mm (1.0 in.) is provided, if the panel thickness is less than or equal to 3.175 mm (0.125 in.). Verification shall be considered successful when the inspection of the drawings or hardware show an access port with a diameter between 12.7 mm (0.5 in.) and 25.4 mm (1.0 in.) is provided for each volume containing a potential fire source if the panel thickness is less than 3.175 mm (0.125 in.).
b. Verification that the design of the CIR permits the PFE nozzle to interface with the access port shall be by demonstration. Verification shall be considered successful when the demonstration shows the design of the CIR, including protrusions, allows the PFE nozzle to interface with the access port over the face of the CIR, without relying on areas adjacent to the CIR.

4.3.6.1.6 Fire suppressant distribution.

Verification that the internal layout of the CIR will allow ISS PFE fire suppressant to be distributed to the entire volume that PFE access port serves, lowering the oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute shall be by analysis or test. Referring to rack qualification tests, which show the ISS PFE will reduce the rack volume oxygen concentration to or below 10.5% by volume within one minute, an analysis shall be performed on the CIR to determine whether or not the internal layout of the integrated rack prevents suppressant from flowing to any volume internal to the volume that PFE access port serves. When verified by test, the test shall be performed to determine whether or not the ISS PFE fire suppressant, as specified in Figure 14, is distributed to the entire volume that PFE access port serves, lowering the oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute. Verification shall be considered successful when the analysis or test shows the internal layout of the CIR will allow ISS PFE fire suppressant to be distributed to the entire volume a PFE access port serves, lowering the oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute.

4.3.6.2 CIR front surface temperature.

Verification that the average CIR front surface temperature and maximum temperature limits will not be exceeded during all modes of operation shall be by analysis or test. The verification shall be considered successful when the analysis or test results show the CIR surface average and maximum limit temperatures are less than those specified.

4.3.6.3 Electrical hazards.

For the CIR, verification of hazard controls shall be by analysis and/or test. The analysis and/or test shall: (1) define the maximum voltage and current profiles to which a crew member might be exposed by the worst case combination of credible failures, events, and/or environments the equipment might experience, and (2) show that the crew is protected by the controls incorporated in the equipment. Verification shall be considered successful when it shows that the appropriate requirements from the following list are satisfied:

a. NVR.
b. The exposure condition exceeds the threshold for shock, but is below the threshold of the let-go current profile (critical hazard) as defined in Table XXI, and two independent controls (e.g., a safety (green) wire, bonding, insulation, leakage current levels below maximum requirements) are provided, and the design of the controls is such that no single failure, event, or environment can eliminate more than one control.
c. The exposure condition exceeds both the threshold for shock and the threshold of the let-go current profile (catastrophic hazardous events) as defined in Table XXI, and three independent controls are provided, and the design of the controls is such that no combination of two failures, events or environments can eliminate more than two controls.
d. If two dependent controls are provided, the physiological effect that a crew member experiences as a result of the combinations of the highest internal voltage applied to or generated within the equipment and the frequency and wave form associated with a worst case credible failure is below the threshold of the let-go current profile as defined in Table XXI.
e. If the analysis fails to clearly define the exposure condition that a crew member might experience, three independent hazard controls are provided and the design of the controls is such that no combination of two failures, events, or environments can eliminate more than two controls.

4.3.6.4 Connector mating.

The design of electrical connectors to preclude inadvertent reversal of connections shall be verified by analysis, inspection, and demonstration. The verification shall be considered successful only when all of the CIR electrical connectors, and wire harnesses requiring crew access to mate/demate during on-orbit operations are demonstrated to meet the requirements.

4.3.6.5 Mating/demating of powered connectors.

Verification that the CIR connected to Interface B meets the loss of power safety requirements specified in NSTS 1700.7, ISS Addendum shall be by analysis. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.

4.3.6.6 Safety-critical circuit redundancy.

Verification that the CIR connected to Interface B meets the loss of power safety requirements specified in NSTS 1700.7, ISS Addendum shall be performed by analysis. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.

4.3.6.7 Rack maintenance switch (rack power switch).

Rack maintenance switch shall be verified by inspection and demonstration. The inspection shall ensure the CIR is equipped with a rack maintenance switch on the front of the CIR. The demonstration shall be performed to ensure the data signals from the rack maintenance switch indicate the designed voltage and current levels expected for both the on and off positions. The verification shall be considered successful when the inspection shows the CIR is equipped with a rack maintenance switch on the front of the CIR and demonstration that data signals from the rack maintenance switch indicates the designed voltage and current levels expected for both the on and off positions.

4.3.6.8 Power switches/controls.

The power switches/controls requirements shall be verified by analysis for power interfaces with open circuit voltage exceeding 30 Vrms or dc nominal (32 Vrms or dc maximum).

a. Switches/controls requirement shall be verified by analysis. An analysis shall be performed to ensure the switches/controls performing on/off functions for all power interfaces open (dead-face) all supply circuit conductors, except the power return and equipment grounding conductor, while in the power-off position. Verification shall be considered successful when analysis of electrical circuit schematics shows the switches/controls performing on/off power functions for all power interfaces open (dead-face) all supply conductors except the power return and equipment grounding conductor, while in the power-off position.
b. Power-off markings and/or indications requirement shall be verified by analysis. The analysis shall ensure power-off markings and/or indications exist when all electrical connections with the power supply circuit are disconnected. The verification shall be considered successful when analysis shows power switches/controls power-off markings and/or indication(s) exist when all electrical connections with the power supply circuit are disconnected.
c. The standby, charging, and descriptive nomenclature requirement shall be verified by analysis. The analysis shall ensure the existence of descriptive nomenclature such as standby, charging, or that necessary to indicate the power supply circuit is not completely disconnected for this power condition. The verification shall be considered successful when analysis shows descriptive nomenclature exists to indicate the power supply circuit is not completely disconnected.

4.3.6.9 Ground fault circuit interrupters (GFCI)/portable equipment dc sourcing voltage.

Ground Fault Circuit Interrupters/portable equipment dc sourcing voltage requirement shall be verified by demonstration, test, and analysis.

a. The analysis of electrical wiring schematics shall ensure a GFCI is in the non-portable utility outlet and is in the power path to portable equipment receiving voltages, exceeding 30 Vrms nominal voltage, or dc nominal voltage (32 Vrms or dc maximum) from a non-portable utility outlet. The verification shall be considered successful when the analysis shows a GFCI is in the non-portable utility outlet and is in the power path between the non-portable utility outlet power source, supplying output voltages exceeding 30 Vrms or dc nominal voltages (32 Vrms or dc maximum), and the load receiving power from the non-portable utility outlet.

b. The test shall ensure the dc trip detection is independent of the portable equipment's safety (green) wire. The verification shall be considered successful when the test shows the dc trip detection does not depend on the current sensing of the portable equipment's safety (green) wire.

c. The test shall ensure the ac trip detection is dependent on the portable equipment's safety (green) wire when the safety (green) wire is present. The verification shall be considered successful when the test shows the ac trip detection depends on the current sensing of the portable equipment's safety (green) wire when the safety (green) wire is present. If an analysis including all the loads which may be connected to the utility outlet shows that ac fault currents do not exist under any failure conditions, this test is not required.

d. The analysis shall ensure the GFCI protection is included within the portable equipment and is in the credible fault path or return path, defined and documented in the Hazard Analysis, for equipment with internal voltages greater than 30 Vrms or dc nominal (32 Vrms or dc maximum). A credible fault/return path within the portable equipment is a fault/return path to a crew member not protected by the GFCI within the utility outlet supplying power to the portable equipment. The test shall ensure that GFCI trips without exceeding the currents specified in Table XXI. The verification shall be considered successful when the analysis shows the GFCI protection is included within the portable equipment and is in the credible fault path or return path to a crew member for portable equipment with nominal voltage above 30 Vrms or dc (32 Vrms or dc maximum) and the test shows GFCI trips before exceeding the current levels specified in Table XXI.

e. The test shall ensure non-portable utility outlets, supplying power to portable equipment, include GFCI that trips without exceeding the currents specified in Table XXII. The verification shall be considered successful when the test shows GFCI, within non-portable utility outlets, trips before exceeding the current levels specified in Table XXI. If an analysis including all the loads which may be connected to the utility outlet shows that ac fault currents do not exist under any failure conditions, this test for ac current is not required.

f. The test shall ensure the GFCI removes power from the output power leads within 25 ms upon encountering the fault current. The verification shall be considered successful when the test shows GFCI removes power from the output power leads within 25 ms upon encountering the fault current.

g. The analysis shall ensure the GFCI provides an on-orbit method for testing the trip current detection threshold at dc and at a frequency within the maximum human sensitivity range of 15 to 70 Hz. The method for the GFCI on-orbit checkout shall be verified by demonstration. The verification shall be considered successful when the analysis shows GFCI provides an on-orbit method and procedure for testing the trip current detection threshold at dc and at a frequency within 15 to 70 Hz, and the demonstration shows that the on-orbit checkout method will trip the GFCI circuit and the GFCI circuit can be manually reset.

4.3.6.10 Portable equipment/power cords.

a. Analysis of schematics shall ensure non-battery powered portable equipment, incorporates a three-wire power cord containing a supply (+) lead, a return (–) lead, and a safety (green) wire. Verification shall be considered successful when the analysis shows the portable equipment/power cords contains a supply (+) lead, a return (–) lead, and a safety (green) wire with one end connected to the portable equipment chassis (and all exposed conductive surfaces) and the other end connected to structure at the utility outlet or though the GFCI interface if GFCI is used. Use of double insulation or its equivalent without the safety (green) wire, when used as an alternative, shall be documented in the CIR ICD as an exception.

b. The analysis shall ensure the fault currents though the credible fault path or return path to the crew member resulting from a single failure at the primary (input) side of the power converter within non-battery powered portable equipment, i.e., portable equipment receiving power from the utility outlet provided by ISS or payload, do not exceed the total peak currents specified in Table XXI for fault current frequencies of 15 Hz and above. Verification shall be considered successful when the analysis shows fault current resulting from a single failure does not exceed the total peak currents specified in the profile shown in Table XXI for fault current frequencies of 15 Hz and above. The verification is not required for portable equipment with internal voltages below 30 Vrms or dc nominal (32 Vrms or dc maximum).

4.3.6.11 Overload protection.

4.3.6.11.1 Device accessibility.

Verification that an overload protective device will not be accessible without opening a door or cover (except operating handles or buttons of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts may project outside the enclosure) shall be by hardware inspection. Verification shall be considered successful when hardware inspection shows a door or cover must be opened to access the overload protective device.

4.3.6.11.2 Extractor-type fuse holder.

Verification that the arrangement of the extractor-type fuse holder operates such that the fuse is extracted when the cap is removed shall be by demonstration. Verification shall be considered successful when demonstrations show the fuse is extracted when the removable cap assembly is removed.

4.3.6.11.3 Overload protection location.

Verification that overload protection (fuses and circuit breakers) intended to be manually replaced or physically reset on-orbit are located where they can be seen and replaced or reset without removing other components shall be by hardware inspection. Verification shall be considered successful when hardware inspection results show that overload protection devices are directly visible and accessible without removal of other components.

4.3.6.11.4 Overload protection identification.

Verification that each overload protector (fuse or circuit breaker), intended to be manually replaced or physically reset on orbit, shall be readily identified or keyed (mechanically or color coded) for its rated value shall be by hardware inspection. Verification shall be considered successful when hardware inspection results show the rated identification for each overload protector is in place.

4.3.6.11.5 Automatic restart protection.

Verification shall be by demonstration. The demonstration shall first induce an "Overload Initiated Shutdown" as defined in SSP 57000, paragraph 3.2.2.6.1.1 and then observe system response to assure that automatic restart does not occur unless the protection switch/control is explicitly operated to enable restarting. The verification of automatic restart protection shall be considered successful when it shows that automatic restart cannot occur following an overload-initiated shutdown without explicit operation of the protection switch/control to enable restarting.

4.3.6.12 Sharp edges and corners protection.

Verification that the hardware meets the sharp edges and corners requirements specified in NSTS 1700.7, ISS Addendum, paragraph 222.1 shall be by inspection of the drawings and assembled CIR hardware. Verification shall be considered successful when the hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.

4.3.6.13 Holes.

An analysis shall be performed using data from drawings, integration documentation, and operational procedures to identify holes in IVA crew member translation paths and maintenance work sites. A drawing inspection shall show that the proper hole sizes have been used or proper guards are in place. Verification shall be considered successful when analysis and inspection shows that all holes are of the proper size, covered, or guarded.

4.3.6.14 Latches.

Verification shall be by inspection. The verification shall be considered successful when the inspection shows that all latches and similar devices have been properly covered or guarded and designed to prevent entrapment of crewmember appendages.

4.3.6.15 Screw and bolts.

Verification shall be by analysis and inspection. An analysis shall be performed using data from drawings, integration documentation, and operational procedures to identify screws and bolts which exceed the length specified in the requirements and the required use of guards or covers due to location in crew member translation paths and maintenance work sites. A drawing inspection shall show that the required cover installation has been accomplished or proper guards are in place. Verification shall be considered successful when analysis and inspection shows that screws and bolts which exceed the specified length have been properly covered or guarded.

4.3.6.16 Securing pins.

An analysis of the CIR hardware and flight drawings shall be performed to verify requirement. The verification shall be considered successful when the analysis shows the requirement has been met.

4.3.6.17 Levers, cranks, hooks, and controls.

Verification shall be by analysis and inspection. The verification shall be considered successful when the inspection and analysis shows that all levers, cranks, hooks, and controls have been properly covered or guarded and cannot pinch, snag, or cut the crew members or their clothing.

4.3.6.18 Burrs.

Verification shall be by inspection. The verification shall be considered successful when the inspection shows that all edges have been properly deburred.

4.3.6.19 Locking wires.

a. An analysis of payload hardware and flight drawings shall be performed to verify requirement. The verification shall be considered successful when the analysis shows the requirement has been met.
b. An inspection of payload hardware or flight drawings shall be performed to verify compliance with the requirement. The verification shall be considered successful when the inspection shows the requirement has been met.

4.3.6.20 Audio devices (displays).

a. Verification that the audio devices and circuits protect against false alarm shall be by analysis. The verification shall be considered complete when analysis shows that protective measures have been taken.
b. Verification of circuit test devices or other means of operability testing shall be by demonstration. The requirement will be met when demonstration shows that the circuit test device correctly indicates when the audio device is working and when it is not working.
c. Verification of the manual disable device shall be by an analysis that determines whether any failure modes can result in sustained activation of the audio device. If no such failure mode exists, then further verification is not required. However, if analysis shows that there are failure modes that can result in sustained activation of the audio device, then demonstration of the manual disable mode shall be required. In that case, the requirement shall be considered successful when demonstration shows that the audio device can be manually turned off.

4.3.6.21 Egress.

Verification of this requirement shall be verified by analysis to show that the crew is not impeded by the CIR in the event of an IVA. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.

4.3.6.22 Failure tolerance.

CIR single fault tolerance for the operation of a computer to identify failures to allow for active troubleshooting shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR single fault tolerance for the operation of a computer identifies failures to allow for active troubleshooting.

4.3.6.23 Failure propagation.

a. Verification of the CIR design that a failure within an assembly will not induce any failure external to the failed assembly shall be by analysis. Verification shall be considered successful when the analysis shows the CIR is designed such that a failure within an assembly will not induce any failure external to the failed assembly.
b. Verification of the CIR design that a failure within the CIR will not induce a failure to any system or component external to the CIR shall be by analysis. Verification shall be considered successful when the analysis shows the CIR is designed such that a failure within the CIR will not induce a failure to any system or component external to the CIR.

4.3.6.24 Separation of redundant paths.

Verification that alternate or redundant electrical functional paths are provided for all paths where electrical or electronic harnesses cannot be replaced on orbit shall be by analysis. Verification shall be considered successful when the analysis shows alternate or redundant electrical functional paths are provided for all paths where electrical or electronic harnesses cannot be replaced on orbit.

4.3.6.25 Incorrect equipment installation.

Verification that the CIR assemblies and components that are replaceable on orbit are designed to contain physical provisions to preclude incorrect installation which may result in damage to equipment or hazardous conditions shall be by analysis. Verification shall be considered successful when the analysis shows the CIR assemblies and components that are replaceable on orbit are designed to contain physical provisions to preclude incorrect installation which may result in damage to equipment or hazardous conditions.

4.3.6.26 Chemical releases.

Verification of this requirement shall be by analysis. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.

4.3.6.27 Single event effect (SEE) ionizing radiation.

Verification that the CIR and assemblies are designed to not produce an unsafe condition or one that could cause damage to equipment external to the CIR as a result of exposure to SEE ionizing radiation shall be by analysis. An analysis of the CIR and assemblies shall be performed using the operational lifetime and parts characterization data to assure that the design meets the requirement when exposed to SEE ionizing radiation. The verification shall be considered successful when the analysis shows that the CIR and assemblies will not produce an unsafe condition or one that could cause damage to equipment external to the CIR when exposed to the specified environment.

4.3.6.28 Potential hazardous conditions.

a. The CIR capability to determine if any out-of-tolerance conditions will lead to a hazardous condition and take steps necessary to prevent the hazardous condition shall be verified by test. The verification shall be considered successful when the test shows the CIR capability to determine if any out-of-tolerance conditions will lead to a hazardous condition and take steps necessary to prevent the hazardous condition.
b. Any autonomous reconfigurations performed to prevent a hazardous condition from occurring capability of being overridden shall be verified by test. The verification shall be considered successful when the test shows that any autonomous reconfigurations performed to prevent a hazardous condition from occurring capability of being overridden.

4.3.6.29 Withstand external environment.

The CIR capability to withstand changes in its external environment to prevent hazardous conditions within the CIR from occurring internal or external to the CIR shall be verified by inspection. The verification shall be considered successful when the CIR successfully completes all the requirements of the PSRP.

4.3.6.30 CIR hazard report requirements.

The following are the specific safety requirements generated from the PSRP CIR Safety Review.

4.3.6.30.1 EMI hazards.

These hazard verifications are covered in paragraph 4.2.6.4.3.18.

4.3.6.30.2 Bottle hazards.

a. Verification that bottle valves contain round handles, which minimizes the possibility of inadvertent opening shall be verified by inspection. The verification shall be considered successful when the inspection shows that bottle valves contain round handles.
b. Bottle valves slow opening, with a minimum of 8 turns to full open capability shall be verified by test. The verification shall be considered successful when the test shows the bottle valves are opened slowly with a minimum of 8 turns.

c. Bottles' self-sealing QD capability shall be verified by test. The verification shall be considered successful when the test shows that the QD is sealed when the bottle is at its full pressure with the manual valve open.
d. Bottle dust caps on QD having six equally spaced radial vent holes to prevent propulsive force shall be verified by inspection. The verification shall be considered successful when the inspection shows the bottle dust caps on QD having six equally spaced radial vent holes.
e. Manual valve preventing fluid flow in the event QD fails and/or non-propulsive cap fails shall be verified by test. The verification shall be considered successful when the test shows the manual valve preventing fluid flow in the event QD fails and/or non-propulsive cap fails by opening the QD with the manual vent valve is closed.
f. Flight operations approved procedures for:
   1. Handling of bottle and valve.
   2. Removal of QD cover.
   3. Attachment into bottle holder, which restrains bottle before opening manual valve.
   Shall be verified by inspection. The verification shall be considered successful when the inspection of the above procedures are complete.
g. All bottle QD's design to hold bottle in place shall be verified by test. The verification shall be considered successful when the test shows all bottle QD's designs hold bottle in place at the full bottle pressures.
h. All bottle holder/restraint design to hold bottle in place in event of QD failure shall be verified by test. The verification shall be considered successful when the test shows the bottle holder/restraint design holds the bottle in place with the full propulsive force of the bottle and a failed QD.

4.3.6.30.3 High oxygen/high pressure hazards.

a. Materials in high oxygen/ high pressure (13790 kPa (2000 psi) portion and materials in low pressure portion (<931 kPa (135 psi)) of fluid system in accordance with MSFC-HDBK-527/JSC 090604/MAPTIS Data base for 85 % oxygen environment shall be verified by inspection. The verification shall be considered successful when the approved Material Identification and Usage List and associated Material Usage Agreements are accepted by GRC and the correct parts were used in the as-built configuration.
b. Supply bottles limited to (13790 kPa (2000 psi) 85% oxygen shall be verified by inspection and test. The inspection verification shall be considered successful when the inspections show the bottles were correctly filled with no more than 85% oxygen. The test verification shall be considered successful when the test shows the bottles contain no more than 85% oxygen.
c. Gas velocities control by designing flow paths without convergence shall be verified by analysis. The verification shall be considered successful when the analysis shows the flow rates are limited using the American Society of Testing and Materials method of analysis.
d. Pressure spikes control by use of slow opening valves and avoidance of dead ends shall be verified by analysis. The verification shall be considered successful when the analysis shows the pressure spikes control by use of slow opening valves and avoidance of dead ends using the American Society of Testing and Materials (ASTM) method of analysis.
e. System design to limit effect of materials shall be verified by analysis. The verification shall be considered successful when the analysis shows the system design to limit effect of

materials using the ASTM method analysis showing materials in the oxygen portion of the system are low impact.

f. High pressure oxygen area cleaned to pure oxygen levels prior to launch shall be verified by inspection. The verification shall be considered successful when the inspection shows the cleaning procedures approval by GRC, the area meets the proper level of cleanliness, and the proper components exposed to oxygen are cleaned to the proper levels.
g. Low pressure oxygen areas design to be cleaned and maintained on orbit to standard fluids cleaning levels shall be verified by inspection. The verification shall be considered successful when the inspection shows the cleaning procedures approval by GRC, the area meets the proper level of cleanliness, and the proper components exposed to oxygen are cleaned to the proper levels.
h. Gas velocities and impingement points limitations in areas exposed to oxygen shall be verified by analysis. The verification shall be considered successful when the analysis shows gas velocities and impingement points in areas exposed to oxygen are limited by using the ASTM method of analysis of the system.
i. The bottle contents, pressure and size limit pressure of O2 rich gas in the chamber to less than half the flammability threshold (for all CIR chamber materials) for specific diluent for O2 percentage are controlled to prevent fires shall be verified by analysis, inspection and test. The analysis verification shall be considered successful when the analysis shows the final chamber pressure would be below one half the ASTM data flammability threshold for the chamber materials after a full bottle at its maximum pressure and highest oxygen concentration is dumped into the chamber. The inspection verification shall be considered successful when the inspection shows the bottles are filled with the proper oxygen concentration and pressure. The test verification shall be considered successful when the post bottle fill test shows the proper oxygen concentration.
j. Oxygen bottle supply ports keyed to allow only O2 bottles to fit only in O2 ports shall be verified by test. The verification shall be considered successful when the test shows oxygen bottle supply ports keyed to allow only O2 bottles to fit only in O2 ports.
k. All bottles/manifold color-coding based on content for crew to have a visual indication of bottle status shall be verified by inspection. The verification shall be considered successful when the inspection shows all bottles/manifold color-coding based on content and approved crew procedures match the color codes.
l. All bottles/manifold are alpha numerically labeled shall be verified by inspection. The verification shall be considered successful when the inspection shows all bottles/manifold are alpha numerically labeled.
m. An Oxygen compatible (materials and cleanliness) check valve in the N2 and diluent supply lines immediately up stream of the O2 junction shall be verified by inspection. The verification shall be considered successful when the inspection of the as built hardware shows the check valves were cleaned per the proper procedures and correctly installed.
n. An Oxygen compatible (materials and cleanliness) solenoid valve in the N2 and Diluent supply lines immediately up stream of the O2 junction shall be verified by inspection. The verification shall be considered successful when the inspection of the as built hardware shows the solenoid valves were cleaned per the proper procedures and correctly installed.

4.3.6.30.4 Leakage hazard.

a. Permanent joints weld integrity shall be verified by inspection and test. The inspection verification shall be considered successful when radiographic inspection of all welds are performed. The test verification shall be considered successful when the proof/leak test at 1.0x MDP and acceptance leak testing after thermal cycling and vibration tests have been successfully performed.
b. For areas where dissimilar metals require joining or maintainability (low number of cycle times) preclude welding non-welded joints used shall be verified by test. The test verification shall be considered successful when the proof/leak test at 1.0x MDP and acceptance leak testing after thermal cycling and vibration tests have been successfully performed.
c. For high cycle make/break seals dual seals used shall be verified by test. The test verification shall be considered successful when the proof/leak test at 1.0x MDP and acceptance leak testing after thermal cycling and vibration tests have been successfully performed.
d. The on orbit leak integrity check shall be verified by inspection and demonstration. The inspection verification shall be considered successful when GRC accepts the approved crew OLIC procedures which include standard maintenance of pressure transducers. The demonstration verification shall be considered successful when the demonstration shows the CIR OLIC can be successfully performed.
e. All items that might be exposed to toxic fluids categorized as fracture critical and meet the fracture control requirements of NASA STD 5003 and SSP 52005 shall be verified by analysis. The verification shall be considered successful when the analysis report is accepted by the PSRP.
f. A separate hazard report generated by each experiment which has the potential to use or produce toxic fluids to evaluate the CIR system in conjunction with the payload for controlling the specific toxic fluids at the levels which will be present shall be verified by inspection. The verification shall be considered successful when the inspection shows that each experiment has included a list of potential toxic fluids used or generated by the experiment.
g. Toxic by-product containing test points cleaning by circulating through an adsorber cartridge shall be verified by analysis and test. The verification shall be considered successful when the analysis and testing of simulated toxic test points show that recirculation brings the toxic test points to acceptable levels.
h. Toxic by-product containing test points shall be vented and back filled with air/nitrogen before crew access to the CIR shall be verified by inspection of approved crew procedures. The verification shall be considered successful when the inspection of the procedures shows venting and back filling before the crew interacts with the CIR.
i. All crew operations which address crew access to the Combustion Chamber performed using approved procedures, including verifying that the clean up and evacuation have been performed shall be verified by inspection. The verification shall be considered acceptable when GRC accepts the approved procedures.
j. Requirement is verified as part of 4.2.8.6.30.4i.
k. Requirement is verified as part of 4.2.8.6.30.4i.
l. Requirement is verified as part of 4.2.8.6.30.4i.
m. Requirement is verified as part of 4.2.8.6.30.4i.

4.3.6.30.5 Chamber door hazards.

a. Chamber door design such that it can only be closed in one way shall be verified by demonstration. The verification shall be considered successful when the demonstration shows the door is designed such that it can only be closed in one way.
b. Chamber door mechanism providing a lock which can only be engaged when door is properly closed shall be verified by demonstration. The verification shall be considered successful when the demonstration shows the chamber door mechanism providing a lock which can only be engaged when door is properly closed.
c. All flight crew operations including closure and opening of the Chamber door performed using approved procedures shall be verified by inspection. The verification shall be considered successful when the approved procedures are accepted by GRC.
d. Chamber door is designed to be self-relieving shall be verified by test. The verification shall be considered successful when the test shows the chamber door is designed to be self-relieving at MDP.
e. Chamber door is designed with required factors of safety for its maximum design pressure (MDP) shall be verified by analysis and test. The verification shall be considered successful when the analysis shows the chamber door stresses are within the safety margins and chamber door passes the proof test at 1.5x MDP.

4.3.6.30.6 Gas flow hazards.

a. A computer processor and mass flow controller combination controlling amounts of oxygen, fuel and diluent in the chamber shall be verified by analysis and test. The analysis verification shall be considered successful when the analysis of the maximum fuel/oxygen/diluent ratios limits the energy to expand the gas due to a temperature rise. The test verification shall be considered successful when the test shows the computer processor and mass flow controller combination controlling amounts of oxygen, fuel and diluent in the chamber.
b. Two independent sets of timers with solenoids/flow restrictors limits fuel flow into chamber shall be verified by inspection and test. The inspection verification shall be considered successful when the approved crew procedures for setting the solenoid timers are accepted by GRC. The test verification shall be considered successful when the tests show the two independent sets of timers with solenoids/flow restrictors limits fuel flow into chamber.

4.3.6.30.7 Oxygen concentration hazards.

High oxygen concentration and fuel bottle sizes, pressures and concentrations controlling for free volume of rack shall be verified by analysis, inspection and test. The analysis verification shall be considered successful when the analysis results indicate the free rack volume compares with the acceptable bottle sizes, bottle pressures and gas concentrations. The inspection verification shall be considered successful when the inspection of the approved filling procedures are accepted by GRC and the proper bottle sizes were used in filling the bottles. The test verification shall be considered successful when the test of the filled bottles show the correct oxygen concentrations.

4.3.6.30.8 Diluent gas bottle hazards.

The bottle size for diluent are sized such that if entire bottle contents were leaked into cabin the O2 of the cabin would not be below 19% shall be verified by inspection and test. The inspection verification shall be considered successful when the inspection of the approved filling procedures are accepted by GRC and the proper bottle sizes were used in filling the bottles. The test verification shall be considered successful when the test of the filled bottles show the correct diluent concentrations.

4.3.6.30.9 Pressure control hazards.

a. The CIR design to incorporate a regulator down stream of each gas source used within the chamber controls pressure to less than 827 kPa(120 psi) shall be verified by test. The verification shall be considered successful when the test shows the CIR design to incorporate a regulator down stream of each gas source used within the chamber controls pressure to less than 827 kPa(120 psi).
b. The CIR design such that pressure switches downstream of the regulators which shut off source solenoids if pressure is above 896 kPa (130 psi) for gases used in the chamber shall be verified by test. The verification shall be considered successful when the test shows the CIR design such that pressure switches downstream of the regulators which shut off source solenoids if pressure is above 896 kPa (130 psi) for gases used in the chamber.
c. The CIR design such that transducers in low pressure section of pressurized subsystem monitored by a controller and all solenoids close if 861 kPa(125 psi) is exceeded for gases used in the chamber shall be verified by test. The verification shall be considered successful when the test shows the CIR design such that transducers in low pressure section of pressurized subsystem monitored by a controller and all solenoids close if 861 kPa(125 psi) is exceeded for gases used in the chamber.
d. The CIR design such that the chamber pressure is monitored by the controller, so that any pressure over specified (experiment dependent but less than 896 kPa (130 psi)) amount and all solenoids shut) shall be verified by test. The verification shall be considered successful when the test shows the CIR design such that the chamber pressure is monitored by the controller, so that any pressure over specified (experiment dependent but less than 896 kPa (130 psi)) amount and all solenoids shut).
e. The CIR design to incorporate a pressure switch in chamber that shuts all supply solenoids if Chamber pressure of 931 kPa (135 psia) is reached shall be verified by test. The verification shall be considered successful when the test shows the CIR design to incorporate a pressure switch in chamber that shuts all supply solenoids if Chamber pressure of 931 kPa (135 psia) is reached.
f. The CIR design such that regulators down stream of the GC carrier gas sources controls pressure to less than 654 kPa (95 psi) shall be verified by analysis and test. The analysis verification shall be considered successful when the flow capability analysis shows the CIR design such that regulators down stream of the GC carrier gas sources controls pressure to less than 654 kPa (95 psi). The test verification shall be considered successful when the test shows the CIR design such that regulators down stream of the GC carrier gas sources controls pressure to less than 654 kPa (95 psi).
g. The CIR design such that redundant relief valves set at 724 and 734 kPa (105 and 107 psi) relieve in the event of a regulator failure, so that the worst case flow will not exceed

individual relief valve maximum flow capability shall be verified by analysis and test. The analysis verification shall be considered successful when the analysis show the life and replacement cycle of the relief valves. The test verification shall be considered successful when the test show the CIR design such that redundant relief valves set at 724 and 734 kPa (105 and 107 psi) relieve in the event of a regulator failure, so that the worst case flow will not exceed individual relief valve maximum flow capability.

h. The CIR design such that regulators down stream of calibration gas and chamber sample line controls pressure to less than 119kPa (17.2 psi) shall be verified by test. The verification shall be considered successful when the test shows the CIR design such that regulators down stream of calibration gas and chamber sample line controls pressure to less than 119kPa (17.2 psi).
i. The CIR design such that pressure transducers monitor the calibration gas line and chamber sample line respectively, so the computer will shut solenoid valves if pressure is above acceptable value 170 kPa (25 psi) and will open solenoids to vent gas to ISS vent shall be verified by test. The verification shall be considered successful when the test shows the CIR design such that pressure transducers monitor the calibration gas line and chamber sample line respectively, so the computer will shut solenoid valves if pressure is above acceptable value 170 kPa (25 psi) and will open solenoids to vent gas to ISS vent.
j. The CIR design such that pressure switches downsteam of calibration gas and chamber sample line controls pressure to less than 160 kPa (23 psi) by closing solenoid valves shall be verified by test. The verification shall be considered successful when the test shows the CIR design such that pressure switches downsteam of calibration gas and chamber sample line controls pressure to less than 160 kPa (23 psi) by closing solenoid valves.
k. All CIR carrier gas bottle pressures kept below the 2000 psia MDP of carrier gas system shall be verified by test. The verification shall be considered successful when the test shows all CIR carrier gas bottle pressures kept below the 2000 psia MDP of carrier gas system.
l. The CIR design such that two manual valves must be opened to allow chamber to be vented shall be verified by test. The verification shall be considered successful when the test shows the CIR design such that two manual valves must be opened to allow chamber to be vented.
m. The manual vent system shall contain an orifice to control worst case flow from chamber at its MDP to prevent over 40 psi at ISS vent shall be verified by analysis and inspection. The analysis verification shall be considered successful when the analysis show the manual vent system shall contain an orifice to control worst case flow from chamber at its MDP to prevent over 40 psi at ISS. The inspection verification shall be considered successful when the inspection of the as built hardware shows inclusion of the orifice and the approved crew procedures are accepted by GRC.
n. The CIR design such that a regulator at exit of CIR vent system set at below 40 psia regulates downstream pressure shall be verified by test. The verification shall be considered successful when the test shows the CIR design such that a regulator at exit of CIR vent system set at below 40 psia regulates downstream pressure.
o. The CIR design such that a mass flow controller commanded by a computer controls flow based on pressure transducer to ensure down stream pressure below 40 psia shall be verified by analysis and test. The analysis and test verification shall be considered successful when the analysis and test show the CIR design such that a mass flow controller commanded by a computer controls flow based on pressure transducer to ensure down stream pressure below 40 psia.

p. The CIR design such that a pressure switch shuts solenoid valve if 40 psia is reached at vent shall be verified by analysis and test. The analysis and test verification shall be considered successful when the analysis and test show the CIR design such that a pressure switch shuts solenoid valve if 40 psia is reached at vent.

4.3.6.30.10 Pressurization hazards.

a. CIR pressurized subsystem hardware design to the following factors of safety (FS): Combustion Chamber FS = 1.5 X MDP (based on yield) and 2.0 MDP based on ultimate; Gas Bottles FS = 2.0 bottle MDP (based on yield) and 2.5 X MDP (based on ultimate); lines/fittings (<1.5 in.) FS = 4.0 X respective line MDP; other system components FS = 2.5 X respective MDP and all lines, fittings, components are be proof pressure tested to 1.5 X MDP shall be verified by analysis and test. The verification shall be considered successful when the analysis and test show the CIR pressurized subsystem design meets the required factors of safety.
b. Gas bottles design as leak-before-burst pressure vessels and tested in accordance with MIL-STD 1522A as modified by NSTS 1700.7B, paragraph 208.4 shall be verified by inspection and test. The inspection verification shall be considered successful when the inspection of the bottle certifications shows the bottles meet their design requirements. The test verification shall be considered successful when the test shows the gas bottles pass their proof pressure tests.
c. The combustion chamber design as a pressure vessel containing hazardous fluids to comply with the intent of MIL-STD 1522A (Approach A), as modified by NSTS 1700.7B, paragraph 208.4a shall be verified by analysis, inspection and test. The analysis verification shall be considered successful when the analysis shows the vacuum integrity of the chamber, along with the fracture mechanics analysis showing positive margins of safety. The inspection verification shall be considered successful when the non-destructive inspection of the chamber shows no critical initial flaw size. The test verification shall be considered successful when hydrostatic proof testing at 1.5x MDP shows no leakage.
d. Procedures developed to ensure flight bottles are not overfilled during ground operations shall be verified by inspection. The verification shall be considered successful when the procedures are accepted by GRC.
e. Portions of the CIR which will be exposed to vacuum on orbit are designed to withstand an internal vacuum shall be verified by analysis. The verification shall be considered acceptable when the analysis shows the portions of the CIR which will be exposed to vacuum on orbit are designed to withstand an internal vacuum.
f. Metallic materials selected in accordance with FCF-PLN-0036 shall be verified by inspection. The verification shall be considered successful when the materials Identification and Usage List and associated Material Usage Agreements are accepted by GRC.
g. Ground handling procedures developed to preclude damage to flight bottles storage, launch and insertion shall be verified by inspection. The verification shall be considered successful when the procedures are accepted by GRC.
h. Crew procedures for proper handling of bottles on orbit are developed shall be verified by inspection. The verification shall be considered successful when the procedures are accepted by GRC.

4.3.6.30.11 Brittle materials hazard.

a. Structural brittle structural materials exposed to pressure loads design to meet the fracture control requirements of NASA STD 5003 and SSP 52005 using a factor of safety of 3.0 (based on ultimate) times chamber MDP based on the minimum guaranteed tensile strength provided by the manufacture shall be verified by analysis, inspection and test. The analysis verification shall be considered successful when the stress analysis indicates positive margins of safety and the fracture analysis is performed to four times the total use life. The inspection verification shall be considered successful when the inspections of the windows show no flaws before and after acceptance testing and are changed out after their required number of pressure cycles. The test verification shall be considered successful when the test shows no leakage or fracture at the test pressure determined by the fracture mechanics analysis.
b. Chamber windows design to be recessed and covers installed over outside surface of windows to prevent scratching of window during ground handling shall be verified by inspection. The verification shall be considered successful when the inspection shows the as built hardware to be in accordance with the flight drawings.
c. Ground handling procedures developed to preclude damage during buildup and test shall be verified by inspection. The verification shall be considered successful when the procedures are accepted by GRC.
d. The chamber windows design to allow control of on orbit assembly by detailed installation procedures shall be verified by demonstration. The verification shall be considered successful when the demonstration shows the chamber windows design to allow control of on orbit assembly by detailed installation procedures.
e. The design of window to prevent metal to glass contact, no bonding of seal to glass and no contact of coating with seal shall be verified by inspection. The verification shall be considered successful when the inspection of the flight drawings shows the design of window to prevent metal to glass contact, no bonding of seal to glass and no contact of coating with seal.
f. The CIR development on orbit procedures that will be in place to alert crew to possibility of damage to windows shall be verified by inspection. The verification shall be considered successful when the procedures are accepted by GRC.
g. The chamber guide rail tolerances to preclude PI hardware contact with inside surface of (recessed) windows during installation of PI hardware into chamber shall be verified by analysis. The verification shall be considered successful when the analysis shows the chamber guide rail tolerances to preclude PI hardware contact with inside surface of (recessed) windows during installation of PI hardware into chamber.

4.3.6.30.12 Particle hazards.

a. The CIR design such that a 40-micron sintered metal filters are located inside any adsorber cartridge at the inlet and the outlet shall be verified by inspection. The verification shall be considered successful when the inspection shows the proper sized filters have been correctly installed in the adsorber cartridges.
b. The CIR design such that each end of each adsorber cartridge will have a self sealing quick disconnect and a manual valves which will seal off the canister upon removal shall be verified by inspection. The verification shall be considered successful when the inspection shows the proper quick disconnects are correctly installed.

c. The CIR design of adsorber cartridges for minimal dusting shall be verified by analysis, inspection and test. The analysis verification shall be considered successful when the analysis shows the CIR design of adsorber cartridges for minimal dusting. The inspection verification shall be considered successful when the crew procedures for chamber access are accepted by GRC. The test verification shall be considered successful when a flight-like adsorber cartridge shows no particles escaping the cartridge after vibration testing and functional testing shows that particles 50 microns or smaller are evacuated below the 2 mL/m^3 residual.
d. Loading procedure for CIR adsorber cartridges to control particle size to greater than 40 microns are developed shall be verified by inspection. The verification shall be considered successful when the procedures are accepted by GRC.

4.3.6.30.13 Incorrect bottle installation hazards.

This hazard is covered in paragraphs 4.3.3.2.4 and 4.3.6.25.

4.3.6.30.14 Battery hazards.

a. Any CIR assembly requiring a battery install a fuse the ground side of the battery which will be rated to blow below the current limit for the cell shall be verified by inspection. The verification shall be considered successful when the inspection shows the proper sized fuse is installed.
b. Any CIR assembly requiring a battery install a blocking diode will be in place upstream of the battery which will prevent charging shall be verified by inspection. The verification shall be considered successful when the inspection shows the blocking diode is installed.
c. Any CIR assembly requiring a battery to change out battery before it drops below life margin shall be verified by analysis and inspection. The analysis verification shall be considered successful when the analysis predicts the battery change out before it drops below its shelf life margin. The inspection verification shall be considered successful when GRC accepts the battery change out procedure.
d. Any CIR assembly requiring a battery design the battery case sealed corrosion resistant material shall be verified by inspection and test. The inspection verification shall be considered successful when the inspection shows the proper case material and sealing capabilities are use. The test verification shall be considered successful when the test shows the case sealing capabilities.
e. Any CIR assembly requiring a battery design such that the maximum assembly temperature is below rated battery temperature shall be verified by analysis. The verification shall be considered successful when the analysis shows the battery design such that the maximum assembly temperature is below rated battery temperature.

4.3.6.30.15 Large moving masses hazard.

a. Any CIR assembly with the potential of large moving masses having motion dampers which will prevent momentum build up if the crewmember releases the mass shall be verified by analysis and test. The analysis verification shall be considered successful when the analysis shows velocity control for all moving masses above 9.1 kg (20 lbs). The test verification shall be considered successful when the test shows control of the moving mass.

b. Any CIR assembly with the potential of large moving masses having pinchpoints eliminated or covered shall be verified by analysis and inspection. The analysis verification shall be considered successful when the rack mechanisms have been accepted during crew reviews. The inspection verification shall be considered successful when the inspection of the moving assembly shows that all pinchpoints have been eliminated or covered.

4.3.6.30.16 Structural loads hazards.

This hazard verification is covered in paragraphs 4.2.6.4.1 and FCF-PLN-0036.

4.3.6.30.17 Rack door hazards.

a. The CIR development of a configuration check sheet for door mechanism condition for use before launch shall be verified by inspection. The verification shall be considered successful when the configuration check sheet is accepted by GRC.
b. The door latch mechanism design to show positive indicators on door mechanism to show status shall be verified by inspection. The verification shall be considered successful when the inspection shows the indicators function.

4.3.6.30.18 Fluid line and fittings hazards.

a. All CIR pressurized lines and fittings design with an ultimate safety factor greater than or equal to 4.0 X MDP and pressure components (valves and filters) have been designed with a factor of safety greater than or equal to 2.5 X MDP shall be verified by analysis and test. The analysis verification shall be considered successful when the stress analysis shows the required margins of safety are met. The test verification shall be considered successful when the proof tests are the required MDP's are met.
b. All materials used in fluid lines and fittings selected in accordance with FCF-PLN-0036 shall be verified by inspection. The verification shall be considered successful when the material certifications show the proper materials are used.
c. The fluid loop hardware design to be assembled per approved procedures shall be verified by inspection. The verification shall be considered successful when the procedures are accepted by GRC.
d. All quick disconnects design to meet the leak rate requirements specified herein shall be verified by test. The verification shall be considered successful when the test shows the no leakage at 1.0x MDP.

4.3.6.30.19 Thermal hazards.

a. All CIR electrical components design to have a lower temperature at steady state with no cooling than the flammability level of the materials that comprise the components shall be verified by analysis. The verification shall be considered successful when the analysis shows that all CIR electrical components are properly cooled during normal operations and that temperatures of materials are below their flammability threshold in the event of loss of cooling.

b. The CIR design such that active thermal shutdown (monitor of component by IOP) or thermal fuses incorporated into the design to shut off the power in over temperature conditions for those components which have not been proven by analysis to be safe in a loss of cooling situation shall be verified by analysis, inspection and test. The analysis verification shall be considered successful when the analysis shows the shut down capability for critical components. The inspection verification shall be considered successful when the inspection shows the thermal shutdown devices are in place. The test verification shall be considered successful when the test shows the CIR will shut down in the event of loss of water or air cooling.

4.3.6.30.20 High temperature hazards.

a. The CIR ECS design to have a closed-loop thermal control system (incorporates automatic thermal switches to inhibit power to the heat generating component(s) and the system if the cooling loop fails) shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR ECS design to have a closed-loop thermal control system (incorporates automatic thermal switches to inhibit power to the heat generating component(s) and the system if the cooling loop fails).
b. The CIR ECS design to preclude crew contact with surfaces exceeding touch temperature limits (rack doors, proper insulation of components, guards, crew procedures) shall be verified by test. The verification shall be considered successful when the test shows the CIR ECS design to preclude crew contact with surfaces exceeding touch temperature limits (rack doors, proper insulation of components, guards, crew procedures).
c. The ECS design to control temperature at steady state on condition of component shall be verified by analysis. The verification shall be considered successful when the analysis shows the proper controls and monitoring in place.
d. The ECS design for fail-safe thermal control and temperature monitoring (limit on temperature that component will increase or decrease to if failed on, thermal fuse, bi-metal switches) shall be verified by analysis. The verification shall be considered successful when the analysis shows the proper controls and monitoring in place.

4.3.6.30.21 Rotating equipment hazards.

a. CIR rotating equipment analysis for maximum worst case speed of item and for worst case maximum energy in accordance with SSP 52005 shall be verified by analysis. The verification shall be considered successful when the analysis show the worst case speed and kinetic energy level is below 14.24 ft lbs.
b. CIR rotating equipment is contained in accordance with SSP 52005 shall be verified by analysis and inspection. The analysis verification shall be considered successful when the analysis shows adequate containment using the PUNCH equation. The inspection verification shall be considered successful when the inspection shows the flight hardware is in compliance with the analysis.

4.3.6.30.22 Electrical power hazards.

This hazard verification is covered in paragraph 4.3.6.3.

4.3.6.30.23 Shock hazards.

This hazard verification is covered in paragraph 4.3.6.3.

4.3.6.30.24 Laser containment hazard.

a. Laser diodes use design such that no direct optical path to crew personnel exists during normal operations, i.e. optical path from laser diode to chamber during normal operations is contained within enclosures and all windows are covered by build-in light shields and rack door shall be verified by analysis, inspection, and test. The analysis verification shall be considered successful when the analysis of the design shows no direct optical path from the laser during crew operations. The inspection verification shall be considered successful when the inspection shows the as built hardware is in accordance with the drawings. The test verification shall be considered successful when the test shows no laser leakage from the rack and the power output of each diode package is not greater than its design power.
b. Laser diode use compliance with ANSI Z 136.1 shall be verified by analysis. The verification shall be considered successful when the analysis shows laser diode use compliance with ANSI Z 136.1.
c. Power removed from laser diode prior to nominal chamber access or maintenance activities as follows:

Inhibit #1: The laser diode shall be commanded off by the crew using the laptop communicating with the CIR. The solid state control is normally off when not powered.

Inhibit #2: Each rack shall have an EPCE which controls all power into that Rack. The EPCE can be commanded or switched off. The on/off state of the EPCE is monitored via the status lamps on the front of the EPCE shall be verified by analysis and test. The analysis and test verifications shall be considered successful when the analyses and tests show there is no voltage potential to power the laser package.

4.3.6.30.25 Inadvertent gas venting hazards.

a. A computer check that bleed path is shut before opening oxygen supply (or premix supply) or checks that oxygen supply (or fuel supply) is shut before bleeding down O2 manifold (or premix manifold) shall be verified by test. The verification shall be considered successful when the test shows the computer check that bleed path is shut before opening oxygen supply (or premix supply) or checks that oxygen supply (or fuel supply) is shut before bleeding down O2 manifold (or premix manifold).
b. The CIR design of a hardware interlock between the oxygen and premix solenoid valves with a solenoid valve, so that one cannot be powered when the other is powered shall be verified by test. The verification shall be considered successful when the test without software shows the CIR design of a hardware interlock between the oxygen and premix solenoid valves with a solenoid valve, so that one cannot be powered when the other is powered.
c. An additional computer other than the one listed in 3.3.6.30.25a acting as a watch dog over the first computer operation by monitoring the oxygen and premix solenoid valves with a solenoid valve to be sure that the two valves are not open at the same time, so that if the valves are open at the same time the monitoring computer will tell the primary to shut the

valves, and if that fails, the monitoring computer will command the EPCE to cut power to the supply for that portion of the CIR which will cause the normally closed solenoids to close shall be verified by test. The verification shall be considered successful when the test shows the additional computer acts as the watchdog.

4.3.7 Human performance/human engineering.

4.3.7.1 Strength requirements.

a. Normal Operations:
   1. Grip strength shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows that the grip strength required to remove, replace, and operate the CIR and its assemblies are as specified.
   n. Linear forces shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows that the linear forces required to remove, replace, and operate the CIR and its assemblies are as specified.
   o. Torsional forces shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows that the torsional forces required to remove, replace, and operate the CIR and its assemblies are as specified.

b. Maintenance Operations:
   Forces shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows that the strength values required to perform maintenance operations on the CIR and its assemblies are as specified.

4.3.7.2 Adequate crew clearance.

The CIR clearance shall be verified by analysis or demonstration. The analysis shall be based on an evaluation of the drawing(s) with the clearance requirements to perform the tasks using the tools and equipment utilized in CIR installation, operations, and maintenance. The demonstration shall be performed on the flight hardware or hardware which replicates the flight hardware configuration with the tools and equipment utilized in CIR installation, operations, and maintenance. The verification shall be considered successful when the analysis or demonstration shows that the clearance accommodates crew performance of tasks, including tool utilization, and is sufficient to install/de-install, replace, operate, and maintain the CIR, its assemblies, and components.

4.3.7.3 Accessibility.

a. CIR hardware accessibility shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows that the specified accessibility is sufficient to remove, replace, operate, and maintain the CIR equipment.
b. IVA clearances shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows the specified IVA clearances.

4.3.7.4 Full size range accommodation.

Analyses of end item drawings that contain on-orbit crew interfaces shall be performed to verify that CIR hardware accommodates the 5th percentile Japanese female to the 95th percentile American male size measurements, estimated for the year 2000, as specified in SSP 50005, Anthropometric and Biomechanics Related Design data. Drawings of work stations and hardware having crew nominal operations and planned maintenance shall be analyzed to verify that they are sized to meet the functional reach limits for the 5th percentile Japanese female. Drawings of work stations and hardware having crew nominal operations and planned maintenance shall be analyzed to verify that they are sized to not confine the body envelope of the 95th percentile American male.

4.3.7.5 Housekeeping closures and covers.

Design of closures or covers shall be verified by inspection of the integrated rack drawings. Verification shall be considered successful when inspection of the flight hardware confirms compliance with the requirement.

4.3.7.6 Built-in housekeeping control.

a. Design of built-in controls shall be verified by inspection of the integrated rack drawings. Verification shall be considered successful when inspection of the flight hardware confirms compliance with the requirement.
b. Crew access to capture elements shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows that the crew can access the flight hardware capture elements for cleaning or replacement without dispersion of trapped material.

4.3.7.7 One-handed operation.

Verify by demonstration that cleaning equipment and supplies can be operated using only one hand.

4.3.7.8 Acoustic requirements.

4.3.7.8.1 Continuous noise limits.

Verification of continuous noise sources for the CIR shall be verified using a test-correlated analytical model, or some other method approved and documented in FCF-PLN-0023. The analytical model shall include system noise sources and anticipated sub-rack payload complement noise sources. The test-correlated model process is shown in Figure 48. The verification shall be considered successful when the results from the test-correlated analytical model predict the loudest location 0.6 m from the CIR surface exposed to the crew habitable volume, in each of the eight octave bands defined in Table XXI, to be at or below the levels specified in Table XXI for additions, deletions, or configuration changes to any CIR equipment within the CIR.

4.3.7.8.2 Intermittent noise limits.

Verification of intermittent noise sources for the CIR shall be performed using a test-correlated analytical model, or some other method approved and documented in FCF-PLN-0023. A test-correlated model as depicted in Figure 48, or other approved verification method for the integrated rack for maximum rack noise duration as defined in Table XXIII, shall be used to perform CIR analysis. The analysis shall exercise the test-correlated model for every intermittent noise occurrence and quantify the noise characteristics in terms of:

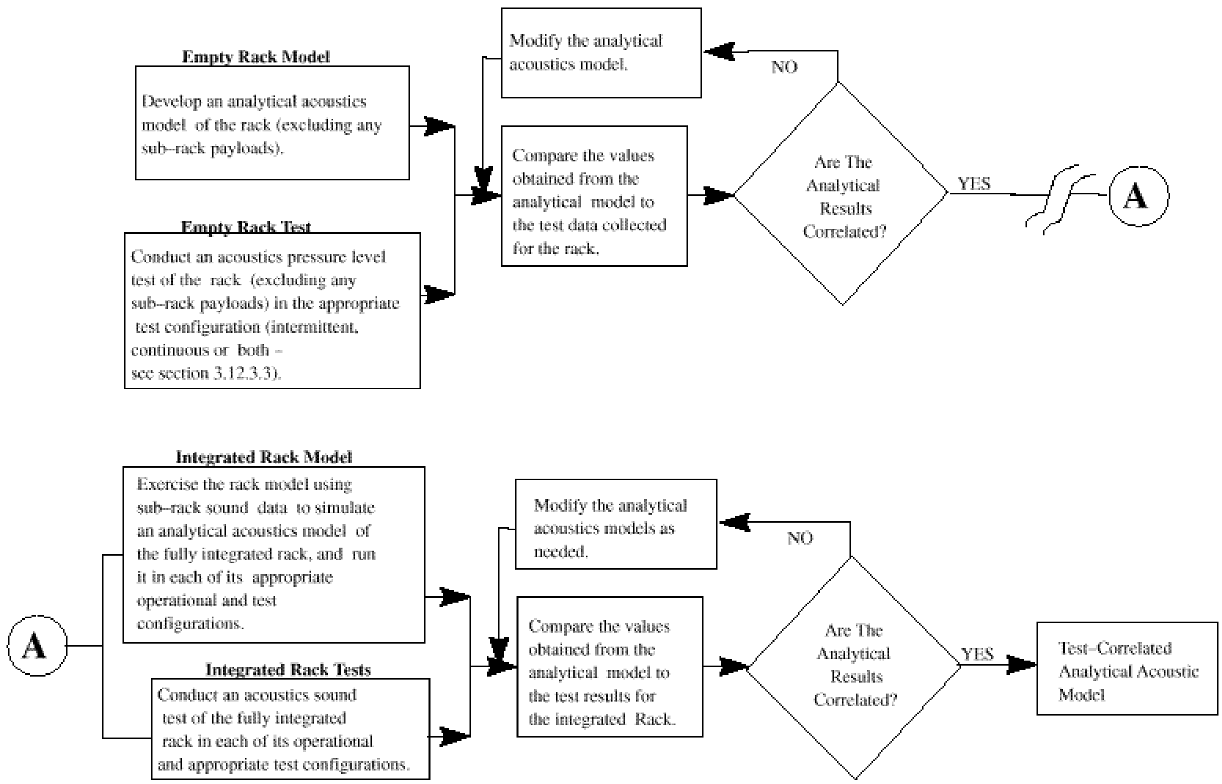


Figure 48. Test correlated model process

When the intermittent sound occurs (a description of what payload activities/operations produce intermittent sound), i.e. a compressor turning on.

1. Duration and SPL (maximum A-weighted SPL measured at a 0.6-m distance from the loudest part of the equipment).
2. A projected mission timeline(s) (a typical CIR scenario that would produce intermittent sound).

The verification shall be considered successful when the results from the test-correlated analytical model predict the A-weighted noise level of the CIR for the maximum rack noise duration to be at or below the levels specified in Table XXIII.

4.3.7.9 CIR hardware mounting.

4.3.7.9.1 Equipment mounting.

Equipment mounting used during nominal operations and planned maintenance shall be verified by analysis or demonstration. The verification shall be considered successful when the analysis or demonstration shows that the CIR hardware used during nominal operations and planned maintenance is designed, labeled, or marked to protect against improper installation.

4.3.7.9.2 Drawers and hinged panel.

Drawers and hinged panels shall be verified by analysis. Verification shall be considered successful when an analysis of the equipment flight drawings shows that any CIR assembly that has to be removed is mounted on equipment drawers or hinged panels and remains in the open position without being supported by the hand.

4.3.7.9.3 Alignment.

Alignment shall be verified by analysis. Verification shall be considered successful when an analysis of the CIR flight hardware drawings shows that guide pins or their equivalent are provided to assist in alignment during installation of hardware with blind mate connectors.

4.3.7.9.4 Slide-out stops.

Slide-out stops shall be verified by inspection, analysis, or demonstration. Verification shall be considered successful when an inspection or analysis of the drawings or demonstration of the CIR flight hardware shows that limit stops are provided on slide or pivot mounted assemblies which are required to be pulled out of their installed positions.

4.3.7.9.5 Push-pull force.

Push-pull forces shall be verified by analysis. Verification shall be considered successful when an analysis of the CIR flight hardware shows that hardware mounted into a capture-type receptacle that requires push-pull action requires a force less than 156 N (35 lbf) to install and remove.

4.3.7.9.6 Access.

Access to inspect or replace a hardware item which is planned to be accessed on a daily or weekly basis shall be verified by analysis or demonstration. Verification shall be considered successful when an analysis of the CIR flight hardware drawings or a demonstration of the CIR flight hardware shows that hardware items which are planned to be accessed on a daily or weekly basis can be inspected and replaced without requiring the removal of an assembly or more than one access cover.

4.3.7.9.7 Covers.

An analysis of CIR hardware and flight drawings shall be performed to verify:

a. Provide a sliding or hinged cap or door where debris, moisture, or other foreign materials might otherwise create a problem.
b. Provide a quick-opening cover plate if a cap will not meet stress requirements.

The verification shall be considered successful when the analysis shows the requirements have been met.

4.3.7.9.8 Self-supporting covers.

Self-supporting covers shall be verified by analysis. Verification shall be considered successful when an analysis of the CIR flight hardware drawings shows that all access covers that are not completely removable are self-supporting in the open position.

4.3.7.9.9 Unique tools.

Unique tools shall be verified by analysis. Verification shall be considered successful when an analysis of the CIR flight hardware drawings meets the requirements of SSP 50005, paragraph 11.2.3.

4.3.7.10 Connectors.

4.3.7.10.1 One-handed operation.

One-handed operation shall be verified by analysis or demonstration. The analysis or demonstration shall be performed on the drawings or flight hardware which replicates the flight configuration. Verification shall be considered successful when the analysis or demonstration shows that all connectors can be mated/demated using only one hand, which does not preclude the use of either hand.

4.3.7.10.2 Accessibility.

a.
   1. Nominal Operations – Accessibility shall be verified by analysis or demonstration. Verification shall be considered successful when an analysis of the CIR flight hardware drawings or demonstration of the CIR flight hardware shows that it is possible to mate/demate individual connectors without having to remove or mate/demate other connectors.
   p. Maintenance Operations – Accessibility shall be verified by analysis or demonstration. Verification shall be considered successful when an analysis of the CIR flight hardware drawings or demonstration of the CIR flight hardware shows that it is possible to mate/demate individual connectors without having to remove or mate/demate connectors on other assemblies or payloads.

b. Accessibility shall be verified by analysis. Verification shall be considered successful when an analysis of the CIR hardware drawings shows that it is possible to disconnect and reconnect electrical connectors and cable installations without damage to wiring connectors.

4.3.7.10.3 Ease of disconnect.

a. Ease of disconnect shall be verified by analysis. Verification shall be considered successful when the analysis shows that electrical connectors which are mated/demated during nominal operations require no more than two turns to disconnect.
b. Ease of disconnect shall be verified by analysis. Verification shall be considered successful when the analysis shows that electrical connectors which are mated/demated only during assembly replacement operations require no more than six turns to disconnect.

4.3.7.10.4 Indication of pressure/flow.

Indication of pressure/flow shall be verified by analysis. Verification shall be considered successful when analysis of CIR flight hardware drawings shows that CIR liquid or gas lines not equipped with quick disconnect connectors which are designed to be connected/disconnected under pressure are fitted with pressure/flow indicators.

4.3.7.10.5 Self locking.

Self locking shall be verified by analysis. Verification shall be considered successful when an analysis of CIR flight hardware drawings shows CIR electrical connectors are provided with a self-locking feature.

4.3.7.10.6 Connector arrangement.

a. Connector arrangement shall be verified by inspection. Verification shall be considered successful when an inspection of the space between connectors and adjacent obstructions comply with the requirement.
b. Connector arrangement shall be verified by inspection. Verification shall be considered successful when an inspection of connectors in a single row or staggered rows complies with the requirements.

4.3.7.10.7 Arc containment.

Arc containment shall be verified by analysis. Verification shall be considered successful when an analysis of the CIR flight hardware drawings shows that electrical connector plugs confine/isolate the mate/demate electrical arcs or sparks.

4.3.7.10.8 Connector protection.

Connector protection shall be verified by analysis. Verification shall be considered successful when an analysis shows that protection is provided for all demated connectors against physical damage and contamination.

4.3.7.10.9 Connector shape.

Connector shape shall be verified by analysis. Verification shall be considered successful when an analysis of CIR flight hardware drawings shows that connectors which differ in content are of different shape or are physically incompatible.

4.3.7.10.10 Fluid and gas line connectors.

The inspection of fluid and gas line connectors that are mated and demated on-orbit shall be verified by analysis. Verification shall be considered successful when an analysis of CIR flight hardware drawings shows that fluid and gas connectors that are mated and demated on-orbit are located and configured so that they can be fully inspected for leakage.

4.3.7.10.11 Alignment marks or pin guides.

Alignment marks or guide pins on mating parts shall be verified by inspection. Verification shall be considered successful when an inspection shows that mating parts have alignment marks in a visible location during mating or guide pins (or their equivalent).

4.3.7.10.12 Orientation.

Orientation shall be verified by analysis. Verification shall be considered successful when an analysis of the CIR flight hardware drawings shows that grouped plugs and receptacles are oriented so that the aligning pins or equivalent devices are in the same relative position.

4.3.7.10.13 Hose/cable restraints.

a. Hose/cable restraints shall be verified by inspection. Verification shall be considered successful when an inspection shows that the loose ends of hoses and cables have a means of being restrained.
b. Hose/cable restraints shall be verified by inspection. Verification shall be considered successful when an inspection shows that conductors, bundles, or cables are secured by a means of clamps unless they are contained in wiring ducts or cable retractors.
c. NVR.
d. Hose/cable restraints shall be verified by inspection. Verification shall be considered successful when an inspection shows that loose cables are restrained as specified.

4.3.7.11 Fasteners.

4.3.7.11.1 Non-threaded fasteners status indication.

Non-threaded fastener status indication shall be verified by demonstration or inspection. Verification shall be considered successful when demonstration or inspection shows that an indication of correct engagement (hooking, latch fastening, or proper positioning of interfacing parts) of non-threaded fasteners shall be provided.

4.3.7.11.2 Mounting bolt/fastener spacing.

Mounting bolt/fastener spacing shall be verified by inspection. Verification shall be considered successful when an inspection shows that mounting bolts and fasteners are spaced as specified.

4.3.7.11.3 Multiple fasteners.

Multiple fasteners shall be verified by inspection. Verification shall be considered successful when an inspection shows that when several fasteners are used on one item they are all of identical type.

4.3.7.11.4 Captive fasteners.

Captive fasteners shall be verified by analysis. Verification shall be considered successful when an analysis shows that fasteners planned to be installed and/or removed on orbit are captive when disengaged.

4.3.7.11.5 Quick release fasteners.

a. Quick release fasteners shall be verified by inspection. Verification shall be considered successful when an inspection shows that fasteners require a maximum of one complete turn to operate.
b. Quick release fasteners shall be verified by inspection. Verification shall be considered successful when an inspection shows that fasteners are positive locking in open and closed positions.

4.3.7.11.6 Threaded fasteners.

Threaded fasteners shall be verified by inspection. The inspection shall be of the drawings. Verification shall be considered successful when the inspection shows that all threaded fasteners are right handed.

4.3.7.11.7 Over center latches.

a. Over center latches shall be verified by inspection. Verification shall be considered successful when an inspection shows that there is a provision to prevent undesired latch element realignment, interface, or reengagement.

b. Over center latches shall be verified by inspection. Verification shall be considered successful when an inspection shows that latch catches have locking features.
c. Over center latches shall be verified by inspection. Verification shall be considered successful when an inspection shows that the latch handle and latch release are operable by one hand.

4.3.7.11.8 Winghead fasteners.

Winghead fasteners shall be verified by inspection. Verification shall be considered successful when an inspection shows that winghead fasteners fold and are retained flush with surfaces.

4.3.7.11.9 Fasteners head type.

a. The hex type external or internal grip or combination head fastener type shall be verified by inspection. The inspection shall be of the hardware or the drawings and parts list. Verification shall be considered successful when an inspection shows that the hex type external or internal grip or combination head fasteners are used for all on-orbit crew actuated equipment.
b. The use of flush or oval head internal hex grip fastener head type on smooth surfaces shall be verified by inspection. The inspection shall be of the hardware or the drawings and parts list. Verification shall be considered successful when an inspection shows that, when a smooth surface is required, only flush or oval head internal hex grip fastener head types are used.
c. The verification that straight-slot fasteners are not used to carry launch loads for hard-mounted equipment shall be by inspection. The inspection shall be of the hardware or the drawings and parts list. Verification shall be considered successful when an inspection shows that straight-slot fasteners are not being used to carry launch loads for hard-mounted equipment.

4.3.7.11.10 One-handed operation.

One-handed operation shall be verified by analysis or demonstration. The analysis or demonstration shall be performed on the drawings, flight hardware, or hardware which replicates the flight hardware configuration. Verification shall be considered successful when the demonstration shows that fasteners planned to be removed or installed on orbit can be mated/demated using only one hand, which does not preclude the use of either hand.

4.3.7.11.11 Access holes.

Access holes shall be verified by inspection. Verification shall be considered successful when an inspection shows that covers or shields though which mounting fasteners must pass for attachment to the basic chassis of the unit shall have holes for passage of the fastener without precise alignment.

4.3.7.12 Controls and displays.

4.3.7.12.1 Controls spacing design requirements.

Controls spacing design shall be verified by inspection. Verification shall be considered successful when the spacing between controls and adjacent obstructions is as specified.

4.3.7.12.2 Accidental actuation.

4.3.7.12.2.1 Protective methods.

Protective methods to reduce accidental actuation of controls shall be verified by inspection. Verification shall be considered successful when one or more of the conditions called out in subparagraphs a though g of paragraph 3.3.7.12.2.1 are met.

4.3.7.12.2.2 Noninterference.

Noninterference shall be verified by inspection. Verification shall be considered successful when an inspection shows that protection devices do not cover or obscure other displays and controls.

4.3.7.12.2.3 Dead-man controls.

NVR.

4.3.7.12.2.4 Barrier guards.

Barrier guards shall be verified by inspection. Verification shall be considered successful when an inspection shows that the barrier guard spacing is as specified.

4.3.7.12.2.5 Recessed switch protection.

Recessed switch protection shall be verified by inspection. Verification shall be considered successful when an inspection shows that rotary switches that control critical functions, and do not have a barrier guard, are recessed as specified.

4.3.7.12.2.6 Position indication.

Position indication shall be verified by inspection. Verification shall be considered successful when an inspection shows that control position is evident without requiring cover removal.

4.3.7.12.2.7 Hidden controls.

Hidden controls shall be verified by inspection. Verification shall be considered successful when an inspection shows that hidden controls are guarded to protect against inadvertent actuation.

4.3.7.12.2.8 Hand controllers.

Hand controllers shall be verified by inspection. Verification shall be considered successful when an inspection shows that hand controllers have a separate on/off control.

4.3.7.13 Valve controls.

a. Low-torque valve controls shall be verified by inspection. Verification shall be considered successful when an inspection of the CIR flight hardware drawings of valves classified as low-torque are equipped with a central pivot type handle as specified.
b. Intermediate-torque valve controls shall be verified by inspection. Verification shall be considered successful when an inspection of the CIR flight hardware drawings of valves classified as intermediate-torque are equipped with a central pivot or lever type handle as specified.
c. High-torque valve controls shall be verified by inspection. Verification shall be considered successful when an inspection of the CIR flight hardware drawings of valves classified as high-torque valves are equipped with a lever type handle as specified.
d. Handle dimensions shall be verified by inspection. Verification shall be considered successful when an inspection of CIR flight hardware drawings is as specified.
e. Rotary valve controls shall be verified by inspection. Verification shall be considered successful when an inspection shows that rotary valve controls open the valve with a counterclockwise motion.

4.3.7.14 Toggle switches.

Toggle switches shall be verified by inspection. Verification shall be considered successful when an inspection of the flight article drawings is as specified.

4.3.7.15 Restraints and mobility aids.

The design of the CIR shall be verified by demonstration or analysis. Verification shall be considered successful when the CIR installation, operation, and maintenance tasks can be performed using standard crew restraints, mobility aids, and interfaces as specified. The demonstration or analysis shall show adequate clearance for attaching RMA's in a position that 95% and 5% crew can reach and is oriented to perform the installation, operation, and maintenance tasks.

4.3.7.16 Captive parts.

Captive parts shall be verified by inspection. Verification shall be considered successful when an inspection shows that all unrestrained parts that are temporarily removed on orbit are held captive.

4.3.7.17 Handle and grasp area design requirements.

4.3.7.17.1 Handles and restraints.

Verification of portable equipment grasp capability shall be by demonstration or inspection. The demonstration shall utilize personnel with hand dimensions within 10% of Table <TBD 04-04> to demonstrate sufficient grasp capability is provided for the 5th percentile female and 95th percentile male. The inspection shall utilize drawings to verify that a handle or other suitable grasp area is provided for portable equipment. The demonstration or inspection shall be considered successful when it is shown that the portable equipment can be grasped by both 5th percentile and 95th percentile personnel using one hand.

4.3.7.17.2 Handle location/front access.

Handle location and access requirements shall be verified by inspection of the CIR drawings. Verification shall be considered successful when inspection of the flight hardware confirms compliance with the requirement.

4.3.7.17.3 Handle dimensions.

IVA handle dimensions for moveable or portable units shall be verified by analysis or demonstration. The verification shall be considered successful when demonstration of the flight hardware confirms compliance with the requirements.

4.3.7.17.4 Nonfixed handles design requirements.

a. Nonfixed handle stop position shall be verified by analysis and demonstration. The verification shall be considered successful when demonstration of the flight hardware confirms compliance with the requirement.
b. Verification of one-handed operation shall be done by demonstration. The verification shall be considered successful when demonstration of this requirement is met.
c. The incorporation of tactile and/or visual indication of locked/unlocked status shall be verified by inspection and demonstration. The verification shall be considered successful when demonstration of the flight hardware confirms compliance with the requirement.

4.3.8 Design requirements.

NVR.

4.3.8.1 Units of measure.

The CIR use of metric units as its primary unit of measure, except when interfacing with non-metric ISS equipment or lack of availability of metric components precludes it shall be verified by inspection of the CIR drawings and associated deviations and waivers. The verification shall be considered successful when the inspection of the drawings and associated deviations and waivers shows the CIR use of metric units as its primary unit of measure, except when interfacing with non-metric ISS equipment or lack of availability of metric components precludes it.

4.3.8.2 Margins of safety/factor of safety.

The design of the CIR use of factors of safety as specified in NSTS 1700.7: NSTS 1700.7, ISS Addendum: and SSP 52005 shall be verified by inspection of the related analysis documentation. The verification shall be considered successful when the inspection of the documentation relating to the design of the CIR uses factors of safety as specified in NSTS 1700.7: NSTS 1700.7, ISS Addendum: and SSP 52005.

4.3.8.3 Allowable mechanical properties.

Values for mechanical properties of structural materials in their design environment are taken in accordance with MIL-HDBK-05 and MIL-HDBK-27 using the "A" allowable shall be verified by inspection of the related CIR analyses. The verification shall be considered successful when the inspection of the CIR related analyses shows the values for mechanical properties of structural materials in their design environment are taken in accordance with MIL-HDBK-05 and MIL-HDBK-27 using the "A" allowable.

4.3.8.4 Fracture control.

The CIR structure meeting the fracture control requirements as specified in NASA-STD-5003 shall be verified by inspection of the related CIR analyses. The verification shall be considered successful when the inspection of the related analyses shows the CIR structure meeting the fracture control requirements as specified in NASA-STD-5003.

4.3.8.5 End-of-life decommissioning and disposal.

An analysis of lower level verifications shall be performed to show that the CIR can be disassembled on-orbit for decommissioning and disposal. The verification shall be considered successful when the analysis of the lower level verifications shows show that the CIR can be disassembled on-orbit for decommissioning and disposal.

4.4 CIR computer resource requirements.

NVR.

4.4.1 CIR computer software design considerations.

a. The CIR primary processor capability to self-activate and self-test once power is applied to the CIR power interface shall be verified by test. Verification shall be considered successful when the test shows the CIR primary processor can self-activate and self-test once power is applied to the CIR power interface.

b. The CIR integrity of all transmitted files shall be verified by experiment simulation testing. Verification shall be considered successful when experiment simulation tests show the CIR integrity of all transmitted files.
c. A single computer within the CIR coordinating all automated activities performed by the CIR shall be verified by test. The verification shall be considered successful when the test shows the single computer within the CIR coordinating all automated activities performed by the CIR.
d. The CIR use of CAN bus for command and control and for health and status data collection shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR use of CAN bus for command and control and for health and status data collection.
e. The CIR use of fiber optics for transferring all digital image data and inter-rack communications shall be verified by inspection. The verification shall be considered successful when the inspection shows the CIR use of fiber optics for transferring all digital image data and inter-rack communications.
f. All CIR avionics (hardware and software) designs to mitigate the consequences of SEE shall be verified by analysis. The verification shall be considered successful when the analysis show all CIR avionics (hardware and software) designs to mitigate the consequences of SEE.

4.4.1.1 Command and data requirements.

4.4.1.1.1 Word/byte notations.

Verification of the word/byte notations shall be by inspection. The inspection shall consist of a review of the word/byte notations against SSP 52050, paragraph 3.1.1 and SSP 57002, paragraph 3.1.1. Verification shall be considered successful when it is shown that the word/byte notations in the CIR software ICD conforms to SSP 52050, paragraph 3.1.1 and SSP 57002, paragraph 3.1.1.

4.4.1.1.2 Data types.

Verification of the data types shall be by inspection. The inspection shall consist of a review of the data types against SSP 52050, paragraph 3.2.1 and subparagraphs. Verification shall be considered successful when it is shown that the data types in the CIR software ICD conforms to SSP 52050, paragraph 3.2.1 and subparagraphs.

4.4.1.1.3 Data transmissions.

a. Verification of the low rate data link (LRDL) transmissions shall be by inspection. The inspection shall consist of a review of the LRDL data transmissions against D684-10056-01, paragraph 3.4. Verification shall be considered successful when it is shown that the word/byte notations in the CIR software ICD conforms to D684-10056-01, paragraph 3.4.
b. Verification of the medium rate data link (MRDL) transmissions shall be by inspection. The inspection shall consist of a review of the MRDL data transmissions against SSP 52050,paragraph 3.3.3.1. Verification shall be considered successful when it is shown that the word/byte notations in the CIR software ICD conforms to SSP 52050, paragraph 3.3.3.1.

c. Verification of the high rate data link (HRDL) transmissions shall be by inspection. The inspection shall consist of a review of the HRDL data transmissions against CCSDS 701.0-B-2, paragraph 1.6. Verification shall be considered successful when it is shown that the word/byte notations in the CIR software ICD conforms to CCSDS 701.0-B-2, paragraph 1.6.

4.4.1.1.4 Consultative committee for space data systems.

Verification of the CCSDS data for paragraph 3.4.1.1.4 a, b, and c shall be by analysis or test. The analysis shall consist of a review of the CCSDS data in the software design documentation. The test shall consist of a data transmission with the PRCU and inspection of the transmitted data against the SSP 52050 formats. Analysis shall be considered successful when it is shown that in the software design documentation the integrated rack data which is transmitted space to ground is either CCSDS data packets or bitstream and the integrated rack data which is transmitted ground to space or to the payload MDM is CCSDS data packets. Test shall be considered successful when the PRCU correctly receives the CCSDS data.

4.4.1.1.4.1 CCSDS data packets.

Verification of the CCSDS data packet shall be by test. The test shall consist of a data transmission with the PRCU and inspection of the transmitted data against the SSP 52050 formats. Test shall be considered successful when the PRCU correctly receives the CCSDS data packets.

4.4.1.1.4.1.1 CCSDS primary header.

Verification of the CCSDS primary header shall be by test. The test shall consist of a data transmission with the PRCU and inspection of the transmitted data against the SSP 52050 formats. Test shall be considered successful when the PRCU correctly receives the CCSDS primary header.

4.4.1.1.4.1.2 CCSDS secondary header.

Verification of the CCSDS secondary header shall be by test. The test shall consist of a data transmission with the PRCU and inspection of the transmitted data against the SSP 52050 formats. Test shall be considered successful when the PRCU correctly receives the CCSDS secondary header.

4.4.1.1.4.1.3 CCSDS data field.

Verification of the CCSDS data field shall be by test. The test shall consist of a data transmission with the PRCU and inspection of the transmitted data against the SSP 52050 formats. Test shall be considered successful when the PRCU correctly receives the CCSDS data field.

4.4.1.1.4.1.4 CCSDS application process identification field.

Verification of the CCSDS APID field shall be by test. The test shall consist of a data transmission with the PRCU and inspection of the transmitted data against the SSP 52050 formats. Test shall be considered successful when the PRCU correctly receives the CCSDS APID field.

4.4.1.1.4.2 CCSDS time codes.

4.4.1.1.4.2.1 CCSDS unsegmented time.

Verification of the CCSDS unsegmented time shall be by test. The test shall consist of a data transmission with the PRCU and inspection of the transmitted data against the SSP 52050 formats. Verification shall be to test the integrated rack with the PRCU for correct test CCSDS unsegmented time.

4.4.1.1.4.2.2 CCSDS segmented time.

Verification of the CCSDS segmented time shall be by test. The test shall consist of a data transmission with the PRCU and inspection of the transmitted data against the SSP 52050 formats. Verification shall be to test the integrated rack with the PRCU for correct test CCSDS segmented time.

4.4.1.1.5 MIL-STD-1553B low rate data link (LRDL).

Verification of the MIL-STD-1553B LRDL shall be by test. The test shall consist of the CIR Payload Bus Remote Terminal and RT Validation Test Set, provided by ISS, used in the performance of a complete RT Validation in accordance with MIL-HDBK-1553 Notice 1 Appendix A to verify the design. The test shall be considered successful when the CIR Payload Bus Remote Terminal meets the RT Validation test as specified.

4.4.1.1.5.1 Standard messages.

Verification of the standard messages shall be by inspection and test. The test shall consist of the PRCU transmitting and receiving standard messages with the CIR. Test shall be considered successful when the PRCU correctly receives the standard messages.

4.4.1.1.5.2 Commanding.

Verification of the commanding shall be by test. The test shall consist of the PRCU issuing commands to the CIR. Test shall be considered successful when the CIR correctly responds to the commands issued by the PRCU.

4.4.1.1.5.3 Health and status data.

Verification of the health and status data shall be by test and inspection. The test shall consist of the reception to the PRCU of the CIR health and status data. The CIR health and status data shall be tested during checkout with the Payload Rack Checkout Unit (PRCU), the Suitcase Test Environment for Payloads (STEP), or equivalent. The CIR health and status data shall be transmitted into the PRCU, the STEP, or equivalent and logged. Subsequent inspection of the logged data shall verify that it exists as defined in the CIR software ICD. Inspection shall be considered successful when it is shown that the health and status data in the CIR software ICD conforms to the format contained in SSP 52050, Table 3.2.3.5–1 and the data field format specified in SSP 57002, Table A–5. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the health and status data as it is defined in the CIR software ICD.

4.4.1.1.5.4 Safety data.

Verification of the safety data shall be by test. The test shall consist of a transmission of a Class 2, Class 3, and Class 4 Caution and Warning messages and an inspection of the received data against the format of SSP 52050, paragraph 3.2.3.5; SSP 57002, Table A–1; and SSP 57002, Table A–5. Test shall be considered successful when the PRCU correctly receives the safety data.

4.4.1.1.5.5 Caution and warning.

4.4.1.1.5.5.1 Class 2 – warning.

Verification that the CIR formats the caution and warning (C&W) word for the listed warning events shall be by analysis and test. Analysis of the CIR safety hazard reports and CIR safety review data shall identify the types of events identified as warnings that are being monitored. The test shall use the STEP, PRCU, or equivalent to determine whether or not the C&W word in the CIR health and status is formatted as a warning for the events identified as warnings. Verification shall be considered successful when the analysis shows the C&W word is formatted in accordance with SSP 52050, paragraph 3.2.3.5 as a warning for events that are defined as a warning.

4.4.1.1.5.5.2 Class 3 – caution.

Verification that the CIR formats the C&W word for the listed caution events shall be by analysis and test. Analysis of the CIR safety hazard reports and CIR safety review data shall identify the types of events identified as cautions that are being monitored. The test shall use the STEP, PRCU, or equivalent to determine whether or not the C&W word in the CIR health and status is formatted as a caution for the events identified as cautions. Verification shall be considered successful when the analysis shows the C&W word is formatted in accordance with SSP 52050, paragraph 3.2.3.5 as a caution for events that are defined as a caution.

4.4.1.1.5.5.3 Class 4 – advisory.

Verification that the CIR requiring advisories format the C&W word for the listed advisory events shall be by analysis and test. Analysis of proposed CIR advisories shall identify the types of events identified as advisories. The test shall use the STEP, PRCU, or equivalent to determine whether or not the C&W word in the CIR health and status is formatted as an advisory for the events identified as advisories. Verification shall be considered successful when the analysis shows the C&W word is formatted in accordance with SSP 52050, paragraph 3.2.3.5 as an advisory for events that are defined as an advisory.

4.4.1.1.5.6 Service requests.

Verification of the service requests shall be by test. The test shall consist of the reception of the CIR's service request by the PRCU. Verification shall be to test the CIR with the PRCU for correct test service requests.

4.4.1.1.5.7 File transfer.

Verification of the file transfer data shall be by test. The test shall consist of a test for both the request to transfer and the actual transfer of a file with the PRCU. The transmitted file shall be inspected against the received file. Verification shall be to test the CIR with the PRCU for correct test file transfer.

4.4.1.1.5.8 Low rate telemetry.

Verification of low rate telemetry shall be by test. The test shall consist of a test of both the request to transmit and the transmission of low rate telemetry with the PRCU. The transmitted low rate telemetry shall be inspected against the received low rate telemetry. Verification shall be to test the CIR with the PRCU for correct low rate telemetry.

4.4.1.1.5.9 Defined mode codes.

Verification of the defined mode codes shall be by test. The test shall consist of the reception by the test equipment of the CIR Payload Bus Remote Terminal's response to a defined mode code transmitted by the test equipment. Test shall be considered successful when the CIR Payload Bus Remote Terminal correctly responds to the defined mode codes in an RT validation test as defined in MIL-HDBK-1553 Notice 1 Appendix A.

4.4.1.1.5.10 Implemented mode codes.

Verification of the implemented mode codes shall be by test. The test shall consist of the reception by the test equipment of the CIR Payload Bus Remote Terminal's response to an implemented mode code transmitted by the test equipment. Test shall be considered successful when the CIR Payload Bus Remote Terminal correctly responds to the implemented mode codes in a RT validation test as defined in MIL-HDBK-1553 Notice 1 Appendix A.

4.4.1.1.5.11 Illegal commands.

Verification of the illegal commands shall be by test. Verification shall be to test that the CIR Payload Bus Remote Terminal correctly responds to the illegal commands by setting the message error bit in the status word response in an RT validation test as defined in MIL-HDBK-1553 Notice 1 Appendix A. Verification shall be considered successful when the CIR Payload Bus Remote Terminal sets the message error bit when the test equipment sends an illegal command.

4.4.1.1.5.12 LRDL interface characteristics.

a. Verification of P3 and P4 appropriate pinout assignment shall be by inspection. The inspection shall be an inspection of CIR drawings to verify that the P3 and P4 pinout matches the corresponding UIP J3 and J4 pinout respectively. The verification shall be considered successful when the inspection shows that the P3 and P4 connector pinout is appropriate.
b. Verification of the P3 and P4 connector with the requirements of SSQ 21635 shall be by inspection. The inspection shall consist of an inspection of the drawings to identify that the SSQ 21635 requirement is identified on the drawing for the P3 and P4 connectors. Verification shall be to test the integrated rack with the PRCU for correct test of the MIL-STD-1553B to receive and execute commands on P3 and P4 independently with various address assignments at P3 and P4.

4.4.1.1.5.12.1 Remote terminal hardwired address coding.

Verification of the RT hardwired address coding scheme (FCF-DOC-0002, paragraph 3.4.1.5.12.1 subparagraphs a - e) shall be by test. The test shall be performed with the PRCU or equivalent to determine that the CIR responds to all the assigned proper RT hardwired address for the ISPR locations. The test shall be considered successful if it demonstrates that the CIR responds only to the assigned RT hardwired address. Each assigned location shall be tested separately.

4.4.1.1.5.12.2 LRDL signal characteristics.

Verification of the MIL-STD-1553B bus A and bus B that the CIR meets the electrical characteristics in accordance with MIL-STD-1553B and the CIR MIL-STD-1553B terminal characteristics are in accordance with MIL-STD-1553B, paragraph 4.5.2 shall be by test. The test shall consist of the measurement of the LRDL signal characteristics with the RT Validation Test Set. Verification shall be to test the CIR Payload Bus Remote Terminal with RT Validation Test Set for correct test of the MIL-STD-1553B signal characteristics according to MIL-STD-1553B, paragraph 4.5.2 with a MIL-STD-1553B bus analyzer as specified in MIL-HDBK-1553 Notice 1 Appendix A.

4.4.1.1.5.12.3 LRDL cabling.

Verification of the CIR LRDL cable that the CIR MIL-STD-1553B internal wiring characteristics are according to SSQ 21655 for 75 Ω or equivalent, the CIR MIL-STD-1553B internal wiring characteristics are summarized in MIL-STD-1553B, Table 3.3.5.2.3–1, the CIR MIL-STD-1553B internal wiring stub length does not exceed 12 ft (3.65 m) when measured from the internal MIL-STD-1553B Remote Terminal to the ISPR Utility Interface Panel shall be by inspection. Verification shall be considered successful when it is shown that the CIR LRDL cable meets SSQ 21655 for 75 Ω or equivalent.

4.4.1.1.5.12.4 Multi-bus isolation.

Verification of the isolation between the various ISS Payload MIL-STD-1553B data buses shall be by test. The test shall consist of the measurement of the signal isolation between the multiple ISS Payload MIL-STD-1553B data buses of the CIR Payload Bus Remote Terminal in an RT validation test as defined in MIL-HDBK-1553 Notice 1 Appendix A. Verification shall be considered successful when the measurement of the signal isolation between the CIR Payload Bus Remote Terminal's multiple ISS Payload MIL-STD-1553B data buses is no less than 58 dB.

4.4.1.1.6 Medium rate data link (MRDL).

4.4.1.1.6.1 MRDL protocol.

Verification of the MRDL LAN 1 and LAN 2 shall be by inspection and test. Verification shall be by inspection of the CIR MRDL protocol to the CIR software ICD against SSP 52050 and SSP 57002. Verification shall be to test the CIR with the PRCU, for correct test of the MRDL protocol per the ISO/IEC 8802-3 Pics Proforma for 10-Base-T using an Ethernet network analyzer.

4.4.1.1.6.2 CIR protocols on the MRDL.

Verification of the CIR protocols length and format on the MRDL LAN 1 and LAN 2 conform with ISO/IEC 8802-3 10-Base-T protocol in accordance with SSP 52050, paragraph 3.3 and use the CCSDS protocol and gateway protocol in SSP 52050, paragraphs 3.3.4 and 3.3.7 shall be by inspection and test. Verification shall be by inspection of the CIR MRDL protocol to the CIR software ICD against SSP 52050 and SSP 57002. Verification shall be to test the CIR with the PRCU for correct test of the MRDL protocol per the ISO/IEC 8802-3 Pics Proforma for 10-Base-T using an Ethernet network analyzer.

4.4.1.1.6.3 MRDL address.

Verification of the CIR MRDL LAN 1 and LAN 2 unique address have a unique Institute of Electrical and Electronic Engineers (IEEE) issued physical address and the unique address is set prior to the Ethernet terminal going active shall be by inspection and test. Verification shall be by inspection of the CIR MRDL address to the CIR hardware ICD against SSP 57001. Verification shall be to test the CIR with the PRCU for correct test of the MRDL protocol per the ISO/IEC 8802-3 Pics Proforma for 10-Base-T using an Ethernet network analyzer.

4.4.1.1.6.4 CIR MRDL connectivity.

a. Verification of the CIR MRDL connectivity shall be by inspection. Inspection shall be considered successful when it is shown that the CIR drawings in the CIR ICD conform to SSP 57001, paragraph 3.3.3.1.
b. Verification of MRDL data routing shall be by test. The test shall be accomplished with the PRCU or equivalent. The test shall be considered successful when it is shown that MRDL data can be successfully routed to the proper ISS LAN with the correct MRDL address.
c. Internal MRDL verification shall be by test. The test shall be accomplished with the PRCU or equivalent. The test shall be considered successful when it is shown that isolation exists between the CIR internal LAN and the ISS LAN.
d. Verification shall be by analysis. The analysis shall verify that the unique numbers were issued by IEEE or their representative. Verification shall be considered successful when traceability of addresses to IEEE has been shown.

4.4.1.1.6.5 MRDL connector/pin assignments and wire requirements.

a. Verification of P46 and P47 appropriate pin assignment shall be by inspection. The inspection shall be an inspection of CIR drawings to verify that the P46 and P47 pinout matches the corresponding J46 and J47 pinout. The verification shall be considered successful when the inspection shows that the P46 and P47 connector pinout is appropriate.
b. Verification of the P46 and P47 connectors with the requirements of SSQ 21635 shall be by inspection. The inspection shall consist of an inspection of the drawings to identify that the SSQ 21635 requirement is identified on the drawing for the P46 and P47 connectors.
c. Verification of the P46 and P47 wires with the requirements of SSQ 21655 shall be by inspection. The inspection shall consist of an inspection of the drawings to identify that the 100-Ω SSQ 21655 requirement is identified on the drawing for the P46 and P47 wiring. Verification shall be to test the integrated rack with the PRCU for correct test of the MRDL to protocol on P46.

Verification shall be to test the CIR with the PRCU for correct test of the MRDL to protocol on P47.

4.4.1.1.6.6 MRDL signal characteristics.

Verification of the MRDL LAN-1 and LAN-2 signal characteristics shall be by inspection and test. Verification shall be by inspection of the integrated rack MRDL protocol to the CIR hardware ICD against SSP 57001. Verification shall be to test the CIR with the PRCU for correct test of the MRDL signal requirements per the ISO/IEC 8802-3 Pics Proforma for 10-Base-T using an Ethernet network analyzer.

4.4.1.1.6.7 MRDL cable characteristics.

Verification shall be by inspection of the CIR MRDL cable. Verification shall be considered successful when it is shown that the CIR MRDL cable meets SSQ 21655 for 100 Ω or equivalent.

4.4.1.1.6.7.1 Differential characteristic impedance.

Verification of the MRDL LAN-1 and LAN-2 differential characteristic impedance shall be by test. Verification shall be to test the CIR with the PRCU for correct test of the MRDL differential characteristic impedance in accordance with ISO/IEC 8802-3, paragraph 14.4.2.2.

4.4.1.1.7 CIR to high-rate frame multiplexer (HFM) protocols.

The CIR use of the HFM common protocols in accordance with SSP 50184, paragraph 3.3.2 shall be by test. Verification shall be considered successful when inspection of the data shows the use of the HFM common protocols in accordance with SSP 50184, paragraph 3.3.2.

4.4.1.1.7.1 High rate data link (HRDL) physical signaling data rates.

Verification of HRDL physical signaling shall be by test and analysis. Verification of the data rate being a multiple of 0.5 Mbps shall be by test at the CIR.

a. Verification of the CIR data rates is by test and is considered successful when the HRDL data rate is greater than or equal to 0.5 Mbps and less than or equal to the maximum negotiated data rate or 95.0 Mbps, whichever is less.
b. Verification of the CIR data rates is by test and is considered successful when the HRDL data rate is in increments of 0.5 Mbps. All selectable data rates are to be recorded.

4.4.1.1.7.2 Encoding.

Verification of the HRDL encoding shall be by inspection and test. Verification shall be by inspection of the integrated rack HRDL protocol to the CIR hardware ICD against SSP 50184 and SSP 57001. Verification shall be to test the CIR with the PRCU for correct test of the HRDL protocol.

4.4.1.1.7.3 CIR HRDL transmitted optical power.

Verification for the CIR design to transmit a HRDL signal in accordance with SSP 50184, paragraph 3.1.1 at an average optical power greater than -16.75 dBm and less than -8.3 dBm and the CIR transmitted optical power measured at the CIR P7 connector to the ISPR connector interface panel using the Halt symbol shall be to test the CIR with fiber optic power meter per ANSI X3.255, for correct optical power at using the Halt symbol. The perturbations optical power from the test setup are not included in the stated power requirement. The perturbations from the test are to be documented. This test shall be considered successful when the requirement is met or exceeded after the test setup variations are removed from the result.

4.4.1.1.7.4 HRDL fiber optic cable.

Verification shall be by inspection of the CIR HRDL cable. Verification shall be considered successful when it is shown that the CIR HRDL cable meets SSQ 21654 or equivalent.

4.4.1.1.7.5 HRDL fiber optic bend radius.

Verification shall be by inspection of the CIR HRDL cable routing, installation, and handling procedures. Verification shall be considered successful when the inspection shows that the routing, installation, and handling procedures do not cause the cable to be bent in a tighter radius.

4.4.1.1.7.5.1 HRDL connectors and fiber.

a. Verification of P7 appropriate pin assignment shall be by inspection. The inspection shall be an inspection of CIR drawings to verify that the P7 pinout matches the corresponding J7 pinout. The verification shall be considered successful when the inspection shows that the P7 connector pinout is appropriate.
b. Verification that the P7 connector meets the requirements of SSQ 21635 shall be by inspection. The inspection shall consist of an inspection of the drawings to identify that the SSQ 21635 requirement is identified on the drawing for the P7 connector.
c. Verification that the HRDL fiber meets the requirements of SSQ 21635 shall be by inspection. The inspection shall consist of an inspection of the drawings to identify that the SSQ 21635 requirement is identified on the drawing for the HRDL fiber.

4.4.1.1.8 Station support computer (SSC).

a. Verification shall be by inspection. The inspection shall be of flight drawings or hardware. The verification shall be considered successful when the inspection shows that each rack uses no more then one SSC.
b. SSC displays shall be verified by demonstration. The demonstration shall be performed on the flight hardware. Verification shall be considered successful when the demonstration to the Payload Display Review Panel (PDRP) shows the requirements in SSP 50313 have been met.

4.4.1.1.9 CIR national television systems committee (NTSC) video and audio interface requirements.

4.4.1.1.9.1 CIR NTSC video characteristics.

Verification of this requirement is satisfied by performing the test requirement of 4.4.1.2.1. PFM NTSC Fiber Optic Video Characteristics and/or 4.4.1.3.1, NTSC Electrical Video Characteristics.

4.4.1.1.9.2 Pulse frequency modulation NTSC fiber optic video characteristics.

Verification of this requirement is satisfied by performing the test requirement of 4.4.1.2.1. PFM NTSC Fiber Optic Video Characteristics and/or 4.4.1.3.1, NTSC Electrical Video Characteristics.

4.4.1.1.9.3 CIR NTSC PFM video transmitted optical power.

Verification shall be to test the CIR with fiber optic power meter. The perturbations optical power from the test setup are not included in the stated power requirement. The perturbations from the test are to be documented. This test shall be considered successful when the requirement is met or exceeded after the test setup variations are removed from the result.

4.4.1.1.9.4 Fiber optic cable characteristics.

Verification shall be by inspection of the integrated rack fiber optic video cable. Verification shall be considered successful when it is shown that the integrated rack fiber optic video cable meets the requirements in FCF-DOC-0002, paragraph 3.4.1.1.9.5.

4.4.1.1.9.5 PFM NSTC video fiber optic cable bend radius.

Verification shall be by inspection of the integrated rack PFM NTSC video fiber optic cable routing, installation, and handling procedures. Verification shall be considered successful when the inspection shows that the routing, installation, and handling procedures do not cause the cable to be bent in a tighter radius.

4.4.2 Flexibility and expansion.

a. Verification that the CIR software be modifiable via the ISS communication network shall be by test using the PRCU. Verification shall be considered successful when the test shows CIR software can be modified via the ISS communication network using the PRCU.
b. CIR software modularized separate from PI-specific software shall be verified by analysis and test. Analysis verification shall be considered successful when the analysis shows the CIR software modularized separate from PI-specific software. Test verification shall be considered successful when the test shows that the CIR software is modularized separate from PI-specific software.
c. CIR software written in C++ and/or Java programming languages with the exception of COTS software and software classified as time critical shall be verified by inspection. Verification shall be considered successful when the inspection shows the CIR software is written in C++ and/or Java programming languages, with the exceptions as listed above.
d. The CIR capability to transfer internal bus controller (Master) functions from the primary processor to at least one other processor after SAR deployment shall be verified by demonstration using simulated SAR hardware. The verification shall be considered successful when the demonstration shows the CIR capability to transfer internal bus controller (Master) functions from the primary processor to at least one other processor.
e. The CIR throughput utilization of each computer communication bus does not exceed 55% of capacity of any 10-s period unless connected to the SAR shall be verified by test. Verification shall be considered successful when the test shows the CIR throughput utilization of each computer communication bus not exceeding 55% of capacity of any 10-s period without being connected to the SAR.
f. The CIR throughput utilization of each computer communication bus not exceeding 60% of capacity of any 10-s period when connected to the SAR shall be verified by test. Verification shall be considered successful when the test shows the CIR throughput utilization of each

computer communication bus does not exceed 60% of capacity of any 10-s period when connected to the SAR.

g. The CIR volatile memory of all single board computers and associated circuit boards sized such that utilization cannot exceed 55% of the bytes available and 70% of the data read/write rates available unless attached to the SAR shall be by analysis. Verification shall be considered successful when the analysis shows the CIR volatile memory of all single board computers and associated circuit boards is sized such that utilization cannot exceed 55% of the bytes available and 70% of the data read/write rates available without being connected to the SAR.
h. The CIR volatile memory of all single board computers and associated circuit boards sized such that utilization cannot exceed 65% of the bytes available and 80% of the data read/write rates available when attached to the SAR shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR volatile memory of all single board computers and associated circuit boards is sized such that utilization cannot exceed 65% of the bytes available and 80% of the data read/write rates available when attached to the SAR.
i. The CIR nonvolatile memory of all single board computers and associated circuit boards sized such that utilization cannot exceed 50% of the bytes available and 70% of the data read/write rates available unless attached to the SAR shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR nonvolatile memory of all single board computers and associated circuit boards is sized such that utilization cannot exceed 50% of the bytes available and 70% of the data read/write rates available without being attached to the SAR.
j. The CIR nonvolatile memory of all single board computers and associated circuit boards sized such that utilization cannot exceed 80% of the bytes available and 70% of the data read/write rates available unless attached to the SAR shall be verified by analysis. Verification shall be considered successful when the analysis shows the CIR nonvolatile memory of all single board computers and associated circuit boards sized such that utilization cannot exceed 80% of the bytes available and 70% of the data read/write rates available when attached to the SAR.
k. The CIR having all mass storage sized such that utilization cannot exceed 50% of the bytes available and 70% of the data read/write rates available for the particular mass storage, assuming data cannot be offloaded from mass storage during the conduct of an experiment, unless connected to the SAR shall be verified by analysis. Verification shall be considered successful when the analysis shows that all CIR and FIR mass storage is sized such that utilization cannot exceed 50% of the bytes available and 70% of the data read/write rates available for the particular mass storage, assuming data cannot be offloaded from mass storage during the conduct of an experiment, unless connected to the SAR.
l. The CIR having all mass storage sized such that utilization cannot exceed 80% of the bytes available and 70% of the data read/write rates available for the particular mass storage, assuming data cannot be offloaded from mass storage during the conduct of an experiment when connected to the SAR shall be verified by analysis. The verification shall be considered successful when all CIR and FIR mass storage is sized such that utilization cannot exceed 80% of the bytes available and 70% of the data read/write rates available for the particular mass storage, assuming data cannot be offloaded from mass storage during the conduct of an experiment when connected to the SAR.

4.4.3 Software portability.

a. The CIR software design to facilitate migration for programs from systems supporting CIR development shall be verified by test. Verification shall be considered successful when the test shows the CIR software is designed to facilitate migration for programs from systems supporting CIR development using CIR development equipment.
b. The CIR software design to facilitate migration of programs to upgraded hardware and firmware shall be verified by test. Verification shall be considered successful when the test shows the CIR software is designed to facilitate migration of programs to upgraded hardware and firmware using CIR development equipment.

4.4.4 Data date/time stamps.

a. All data date/time stamped as specified in paragraph 3.2.1.35 by the primary computer collecting the data shall be verified by inspection and test. The verifications shall be considered successful when the inspection of test data shows all data date/time stamped as specified in paragraph 3.2.1.35 by the primary computer collecting the data.
b. Data flowing from one computer to another where date/time stamps have been applied not having their date/time stamps overwritten shall be verified by inspection and test. The verifications shall be considered successful when inspection of the test data shows data flowing from one computer to another where date/time stamps have been applied not having their date/time stamps overwritten.

4.5 Logistics.

4.5.1 Maintenance.

The CIR design to allow for changeout, maintenance, and upgrade of hardware and software to conduct the basis experiments as specified in FCF-DOC-002 shall be verified by demonstration. The verification shall be considered successful when the demonstration shows the CIR is designed to allow for changeout, maintenance, and upgrade of hardware and software to conduct the basis experiments as specified in FCF-DOC-002 using flight hardware simulators.

4.5.2 Supply.

The CIR design to perform a minimum of 5 basis-type experiments per year as specified in FCF-DOC-002 using no more than the up-mass and stowage volume resupply requirements as specified in FCF-DOC-0002, paragraph 3.2.2 shall be verified by analysis. The verification shall be considered successful when the analysis shows the CIR is designed to perform a minimum of 5 basis-type experiments per year as specified in FCF-DOC-002 using no more than the up-mass and stowage volume resupply requirements as specified in FCF-DOC-0002, paragraph 3.2.2.

4.5.3 Facilities and facility equipment.

Not applicable.

4.6 Personnel and training.

4.6.1 Personnel.

a. The CIR design to be nominally maintained and operated by one crew member shall be verified by demonstration. The verification shall be considered successful when the demonstration shows the CIR is designed to be nominally maintained and operated by one crew member.
b. The CIR design to be operated using ground commands once experiment setup is completed by the crew shall be verified by test. Verification shall be considered successful when the test shows the CIR is designed to be operated using ground commands once experiment setup is completed by the crew.
c. The CIR design such that no more than two crew members are required for off-nominal and troubleshooting operations shall be verified by demonstration. Verification shall be considered successful when the demonstration shows the CIR is designed such that no more than two crew members are required for off-nominal and troubleshooting operations.

4.6.2 Training.

The CIR design for simple and logical installation, maintenance, and operation to minimize crew training shall be verified by demonstration. Verification shall be considered successful when the demonstration shows the CIR design for simple and logical installation, maintenance, and operation to minimize crew training.

4.7 Major component characteristics.

Verification that the CIR assemblies listed in paragraphs 3.1.6 and 3.1.9 are in accordance with their individual product specification shall be verified by inspection of each assembly's acceptance data package.

4.8 Preparation for delivery.

4.8.1 Preservation.

Not applicable.

4.8.2 Packing.

Packaging, handling, and transportation in accordance with NHB 6000.1 shall be verified by inspection. The verification shall be considered successful when the inspection shows packaging, handling, and transportation in accordance with NHB 6000.1.

4.8.3 Launch configured CIR.

The CIR in its launch configuration, including stowage items required to complete the on-orbit configuration, considered as Class I as specified in NHB 6000.1 shall be verified by inspection.

The verification shall be considered successful when the CIR in its launch configuration, including stowage items required to complete the on-orbit configuration, is considered as Class I as specified in NHB 6000.1.

4.8.3.1 Cleanliness.

All surfaces of all hardware cleaned to the Visibly Clean - Sensitive (VC - S) cleanliness level as specified in SN-C-0005, except for those surfaces that are covered to maintain cleanliness for oxygen usage, shall be verified by inspection. The verification shall be considered successful when all surfaces of all hardware are cleaned to the VC - S cleanliness level as specified in SN-C-0005, except for those surfaces that are covered to maintain cleanliness for oxygen usage.

4.8.3.2 Procedures.

All flight hardware packed according to its specific packing procedures in the designated containers shall be verified by inspection. The verification shall be considered successful when all flight hardware is packed according to its specific packing procedures in the designated containers.

4.8.3.3 Flight spares and other equipment.

Spares and all other CIR equipment considered as Class III or higher as specified in NHB 6000.1 shall be verified by inspection. The verification shall be considered successful when spares and all other CIR equipment are considered as Class III or higher as specified in NHB 6000.1.

4.8.4 Marking and labeling.

Not applicable.

4.8.5 Marking for shipment.

Marking of packaging containing pressurized gases and chemicals in accordance with Department of Transportation regulations shall be verified by inspection. The verification shall be considered successful when marking of packaging containing pressurized gases and chemicals is in accordance with Department of Transportation regulations.

4.9 Precedence.

All specifications, standards, exhibits, drawings, or other documents that are referenced in this specification are hereby incorporated as cited, with the exception of those documents specifically cited to be used for reference only.

5.0 PREPARATION FOR DELIVERY

This section gives the requirements for the preservation, packing, marking, and labeling of the CIR and its associated flight hardware for shipment to the launch site.

5.1 Preservation.

Not applicable.

5.2 Packing.

Packaging, handling, and transportation shall be in accordance with NHB 6000.1

5.2.1 Launch configured CIR.

The CIR in its launch configuration, including stowage items required to complete the on orbit configuration, shall be considered as Class I as specified in NHB 6000.1.

5.2.1.1 Cleanliness.

All surfaces of all hardware shall be cleaned to the VC - S cleanliness level as specified in SN-C-0005, except for those surfaces that are covered to maintain cleanliness for oxygen usage.

5.2.1.2 Procedures.

All flight hardware shall be packed according to its specific packing procedures in the designated containers.

5.2.2 Flight spares and other equipment.

Spares and all other CIR equipment shall be considered as Class III or higher as specified in NHB 6000.1.

5.3 Marking and labeling.

Not applicable.

5.4 Marking for shipment.

Marking of packaging containing pressurized gases and chemicals shall be in accordance with Department of Transportation regulations.

6.0 NOTES

There are no notes at this time.

APPENDIX A ACRONYMS AND ABBREVIATIONS

A.1 Scope.

This appendix lists the acronyms and abbreviations used in this document.

A.2 List of acronyms and abbreviations.

A	amperes
A_i	inherent availability
ac	alternating current
APID	application process identification
APM	Attached Pressurized Module
ARIS	Active Rack Isolation System
ATCA	Air Thermal Control Assembly
ATCS	Air Thermal Control System
atm	atmospheres
AWG	average wire gauge
BIT	built-in-test
C	centigrade, Celsius
cc	cubic centimeter
CCS	Calendar Segmented Time Code
CCSDS	Consultative Committee for Space Data Systems
CIR	Combustion Integrated Rack
CFU/m^3	Colony Forming Units/cubic meter
cm	centimeter
COF	Columbus Orbital Facility
COTS	commercial-off-the-shelf
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
CUC	Unsegmented Time Code
C&W	caution and warning
dB	decibels
dBA	acoustic decibel level
dBm	decibels referenced to 1 mW
dc	direct current
deg	degrees
DOORS	Dynamic Object Oriented Requirements System
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EPCE	Electrical Power Consuming Equipment
EPCU	Electrical Power Control Unit
EPS	Electrical Power System
equiv.	equivalent
ESA	European Space Agency
ESD	electrostatic discharge
F	Fahrenheit

fc	foot-candles
FCF	Fluids and Combustion Facility
FCU	FOMA Control Unit
FEM	finite element modeling
FIR	Fluids Integrated Rack
FOMA	Fuel/Oxidizer Management Assembly
ft	feet
g	gravity
g^2/Hz	gravity squared/Hertz
GC	Gas Chromatograph
GFCI	Ground Fault Circuit Interrupters
GN2	gaseous nitrogen
GRC	Glenn Research Center
grms	gravity-root mean square
GSE	Ground Support Equipment
H	Halt symbol
HDRL	high rate data link
HFR	high frame rate
HiBMs	High Bit Depth/Multi-spectral
H	high resolution
HFM	high-rate frame multiplexer
Hz	Hertz
ICD	Interface Control Document
IDD	Interface Definition Document
IEEE	Institute of Electrical and Electronic Engineers
in.	inches
in-lb	inch-pounds
IOP	Input/Output Package
IPP	Image Processing Package
IR	infrared
IRD	Interface Requirements Document
IRE	Institute of Radio Engineers
ISPR	International Standard Payload Rack
ISS	International Space Station
ITCS	Internal Thermal Control System
IVA	Intravehicular Activity
IVS	Internal Video Subsystem
J	joules
JSC	Johnson Space Center
K	Kelvin
kg	kilograms
kg/h	kilograms per hour
KSC	Kennedy Space Center
kPa	kilopascals
LAN	local area network
lbs	pounds

lbf	pounds force
lbm	pounds per minute
LED	Light Emitting Diode
LISN	Line Impedance Simulation Network
LRDL	low rate data link
LSB	Least Significant Bit
M	meter
mA	milliampere
Mbits	megabits
Mbps	megabytes per second
MDM	Multiplexer-Demultiplexer
MDP	Maximum Design Pressure
MHz	megahertz
mm	millimeter
MMCH/Y	mean maintenance crew hours per year
mod.	modification
mph	miles per hour
MPLM	Multi-Purpose Logistics Module
MRDL	medium rate data link
ms	millisecond
m/s	meter/second
msec	millisecond
MSFC	Marshall Space Flight Center
MTBM	mean time between maintenance
MDT	mean delay time
MTTF	mean time to failure
MTTR	mean time to repair
N	Newton
N_2	nitrogen
N/A	Not applicable
NASDA	National Space Development Agency of Japan
NIRA	Non-Isolated Rack Assessment
nF	nanofarad
NIST	National Institute of Standards and Technology
nm	nanometer
N-m	Newton-meter
NRZI	Non Return to Zero Event
ns	nanosecond
NTSC	National Television Systems Committee
NVR	No verification required
O_2	oxygen
ORU	Orbital Replacement Unit
oz	ounces
Pa	Pascals
PCS	Portable Computer System
PFE	Portable Fire Extinguisher

PFM	Pulse Frequency Modulation
pf/m	picofarad per meter
PI	Principal Investigator
PIN	Part Identification Number
PDRP	Payload Display Review Panel
PRCU	Payload Rack Checkout Unit
psi	pounds per square inch
psia	pounds per square inch absolute
PSRP	Payload Safety Review Panel
PUL	Portable Utility Light
PVP	Payload Verification Plan
QD	quick disconnect
ref.	reference
rev.	revision
RH	relative humidity
RHA	Rack Handling Adapters
RMSA	Rack Maintenance Switch Assembly
RPC	Remote Power Controller
RPCM	Remote Control Power Module
RT	Remote Terminal
RUP	Rack Utility Panel
SAMS	Spacecraft Acceleration Measurement System
SAR	Shared Accommodations Rack
scc	standard cubic centimeter
SD	standard deviation
sec	second
SEE	single event effect
SMAC	Spacecraft Maximum Acceptable Concentration
SPL	sound pressure level
SRD	Science Requirements Document
SSC	Station Support Computer
STEP	Suitcase Test Environment for Payloads
TBC	To be confirmed
TBD	To be determined
TBE	Teledyne Brown Engineering
TCS	Thermal Control System
temp.	temperature
UIP	Utility Interface Panel
UOP	Utility Outlet Panel
US Lab	United States Laboratory Module
UV	ultraviolet
VC - S	Visibly Clean - Sensitive
Vdc	voltage direct current
VES/WGS	Vacuum Exhaust System/Waste Gas System
Vrms	voltage root mean square
W	watts

WFCA	Water Flow Control Valve
WTCS	Water Thermal Control System
μA	microampere
μg	microgravity
μsec	microsecond
Ω	ohm

APPENDIX B DEFINITIONS

B.1 Scope.

This section defines special terminology used in this document.

B.2 Definitions.

access port: Hole that allows penetration of the Portable Fire Extinguisher nozzle.

Adjunct Active Portable Equipment: Equipment operated outside the rack required to support nominal payload operations (including any required GFE).

acoustic reference: All sound pressure levels in decibels are referenced to 20 μPa.

active air exchange: Forced convection between two volumes. For example, forced convection between a subrack payload and the internal volume of an integrated rack, or forced convection between a subrack payload and the cabin air.

alignment marks: Straight or curved lines of sufficient length and width to allow alignment; applied to both mating parts. Align when the parts are in the installation position, and are visible during alignment and attachment.

amu (One Atomic Mass Unit): Equal to one-twelfth the mass of a carbon-12 atom; tile average atomic mass is called the atomic weight.

Applicable PI hardware/software: Hardware/software provided by the PI experiment required to perform a NASA Research Announcement experiment in the CIR.

boss: Protruding hard-points for GSE attachment.

brightness ratio: The ratio of the maximum light level on the work surface area to the minimum light level on the work surface area.

catastrophic hazard: Any hazard which causes loss of on orbit life sustaining system function.

Common Mode Noise: Refer to SSP 30482.

commonality: Identical in form, fit, and function.

Continuous Noise Source: A significant noise source which exists for a cumulative total of 8 hours or more in any 24-hour period.

critical hazard: Any hazard which may cause a non-disabling injury, severe occupational illness, loss of emergency procedures, or major damage to one of the following: the launch or servicing vehicle, manned base, an on orbit life sustaining function, a ground facility, or any critical support facility.

current limiting: The current is limited to a specific level plus or minus a percentage for tolerance.

detergent wipes: Detergent-saturated tissues used for interior surfaces and window cleaning.

disinfecting wipes: Tissue saturated with a disinfecting cleansing agent or agents for cleanup of biological spills and biologically contaminated surfaces.

dry wipes: Utility wipes used for compartment and equipment cleaning and spill clean-up.

electromagnetic compatibility (EMC): The capability of systems and all associated subsystems/equipment to perform within design limits without degradation due to the Electromagnetic Effect encountered during accomplishment of the assigned mission. The deliverable end item compatibility test is as described in paragraph 3.6.2 of SSP 30243.

electromagnetic interference (EMI): Any electromagnetic disturbance, phenomenon, signal, or emission (man-made or natural) which causes equipment performance outside of the equipment's design limits. Testing is described in SSP 30237 and SSP 30238, as referenced by SSP 57000, paragraph 3.2.4.4.

emergency condition: Toxic atmosphere, rapid cabin depressurization, or fire.

EPCE: Equipment that consumes electrical power including battery powered equipment.

fire event: Localized or propagating combustion, pyrolysis, smoldering, or other thermal degradation process characterized by the potentially hazardous release of energy, particulates, or gasses.

GSE Plane: A reference plane that is defined by the front surface of the four rack GSE bosses.

hazard: The presence of a potential risk situation caused by an unsafe act or condition.

health and status data: Information originating at the payload and passed to the respective payload MDM that provides the crew and the ground confirmation of payload performance, operational state, resource consumption, and assurance that the payload is operating within the safety guidelines as defined by the Payload Safety Review Panel and the ISS Flight Rules. Some examples of payload health and status data are subsystem status (power, voltages, currents, temperatures, pressures, fluid flow velocities, warning indicators, error messages/codes, etc.), digital communications system statistics (1553, Ethernet, and high rate system status, etc.), and video system status (camera and video recorder on/off indications, synchonization indicators, etc.).

integrated rack: The ISPR and all other subrack equipment which operates within a rack.

Intermittent Noise Source: A significant noise source which exists for a cumulative total of less than 8 hours in a 24-hour period.

Line Impedance Stabilization Network: An electrical circuit, including resistance, capacitance, and inductance, used to simulate a specific electrical power bus.

maintenance: The scheduled or unscheduled activity (inspections, preventive and corrective actions, restorations, replacement of assemblies and components, and resupply operations) intended to keep the proper functioning of CIR hardware and software.

maintenance item: Any assembly or component designed to be replaceable on orbit to maintain the proper functioning of CIR hardware.

mils: Length measurement equal to 0.001 in.

non-normal: Pertaining to performance of the Electrical Power System outside the nominal design due to ISS system equipment failure, fault clearing, or overload conditions.

On orbit Momentary Protrusions: Payload obstructions which typically would protrude for a very short time or could be readily eliminated by the crew at any time. Momentary protrusions include only the following: drawer/door/cover replacement or closure.

On orbit Permanent Protrusion: A payload hardware item which is not ever intended to be removed.

On orbit Protrusions for Keep Alive Payloads: A protrusion which supports and/or provides the uninterrupted resources necessary to run an experiment. On orbit protrusions for Keep Alive Payloads includes only power/data cables and thermal hoses.

On orbit Semi-Permanent Protrusion: A payload hardware item which is typically left in place but can be removed by the crew with hand operations or standard IVA tools.

> Example: SIR and ISIS drawer handles, other equipment that does not interfere with crew restraints, and mobility aids.

On orbit Temporary Protrusion: A payload item which is typically located in the aisle for experiment purposes only. These items should be returned to their stowed configuration when not being used.

> Example: Front panel mounted equipment.

operate: Perform intended design functions given specified conditions.

Orbital Replacement Unit: Any unit mounted to the exterior of an assembly that can be removed and replaced with an identical unit while on orbit. Items internal to hardware, such as electronic circuit boards and internal disk drives, are not considered ORU’s.

out-of-tolerance: Any condition outside of normal or specified operational limits.

potential fire source: Any electrical, chemical, or other energy source capable of creating a fire event (e.g., electrically powered equipment).

protrusion: A payload hardware item which extends beyond the GSE plane.

rack equivalent: The volume equal to the total internal volume of one empty ISPR.

reusable wipes: Utility handwipes that can be impregnated or dampened with premixed evaporative detergent/biocidal solutions or with water.

safety-critical: Having the potential to be hazardous to the safety of hardware, software, and personnel.

specularity: The ratio of the flux leaving a surface or medium by regular (specular) reflection to the incident flux.

standard conditions: Measured volumes of gasses are generally recalculated to 0°C temperature and 760 mm Hg pressure, which have been arbitrarily chosen as standard conditions.

training: To educate people in the design, operation, maintenance, and troubleshooting aspects of the CIR.

up-mass: The mass of equipment to be transported from the ground to the ISS.

up-volume: The volume of equipment to be transported from the ground to the ISS.

vented conditions: Condition (temperature and pressure) of the gas in the experiment chamber as the chamber is opened to the ISS VES/VGS.

VES/WGS: Vacuum Exhaust System and/or Waste Gas System. The USL, JEM, and APM each have similar systems to vent gases to space from an experiment chamber. The system in the USL is the Vacuum Exhaust System and the systems in the JEM and APM are the Waste Gas Systems.

wire derating: Wire is derated based on the current flow, environment, and electrical circuitry that operates within an integrated rack or within Electrical Power Consuming Equipment individual boxes.

APPENDIX C STRUCTURAL INTERNAL PHYSICAL INTERFACES

C.1 Scope.

This section gives the CIR internal structural interfaces.

C.2 CIR internal physical interfaces.

The CIR internal structural interface descriptions are given in below. The detailed definitions are given in CIR-SPC-0115.

C.2.1 ISPR rack to CIR attachment interfaces.

Connection From	Connection Description	Connection To	Connection Description
ATCU Rack Attachment Bracket	TBD C2-01	ISPR	TBD C2-01
ATCU Rack Attachment Bracket	TBD C2-01	ATCU	TBD C2-01
Optics Bench Rack Attachment Bracket	TBD C2-01	ISPR	TBD C2-01
Optics Bench Rack Attachment Bracket	TBD C2-01	Optics Bench	TBD C2-01
EPCU Rack Attachment Bracket	TBD C2-01	ISPR	TBD C2-01
EPCU Rack Attachment Bracket	TBD C2-01	EPCU	TBD C2-01
IOP Rack Attachment Bracket	TBD C2-01	ISRR	TBD C2-01
IOP Rack Attachment Bracket	TBD C2-01	IOP	TBD C2-01
Center Post Bracket	TBD C2-01	ISPR	TBD C2-01
Center Post Bracket	TBD C2-01	Center Post	TBD C2-01
Optics Bench Slide Rack Attachment Bracket	TBD C2-01	ISPR	TBD C2-01
Optics Bench Slide Rack Attachment Bracket	TBD C2-01	Optics Bench Slide	TBD C2-01
GIS Rack Attachment Bracket	TBD C2-01	ISPR	TBD C2-01
GIS Rack Attachment Bracket	TBD C2-01	GIS	TBD C2-01
Smoke Detector Rack Attachment Bracket	TBD C2-01	ISPR	TBD C2-01
Smoke Detector Rack Attachment Bracket	TBD C2-01	Smoke Detector	TBD C2-01
WTCS Rack Attachment Bracket	TBD C2-01	ISPR	TBD C2-01
WTCS Rack Attachment Bracket	TBD C2-01	WTCS	TBD C2-01

C.2.2 CIR component to optics bench attachment.

Connection From	Connection Description	Connection To	Connection Description
High Percentage Oxygen Supply Manifold	TBD C2-02	Optics Bench	TBD C2-02
Diluent/Premixed Supply Manifold	TBD C2-02	Optics Bench	TBD C2-02
Nitrogen/High Pressure Supply Manifold	TBD C2-02	Optics Bench	TBD C2-02
Fuel/Pre-mixed Fuel Supply Manifold	TBD C2-02	Optics Bench	TBD C2-02
Exhaust Vent Manifold	TBD C2-02	Optics Bench	TBD C2-02
Adsorber Cartridge Brackets	TBD C2-02	Optics Bench	TBD C2-02
Manual Vent Valve Manifold	TBD C2-02	Optics Bench	TBD C2-02
GC Supply Manifold Brackets	TBD C2-02	Optics Bench	TBD C2-02
Gas Chromatograph	TBD C2-02	Optics Bench	TBD C2-02
SAMS Head	TBD C2-02	Optics Bench	TBD C2-02
Oxygen Senor Enclosure	TBD C2-02	Optics Bench	TBD C2-02
Valve timers Enclosure	TBD C2-02	Optics Bench	TBD C2-02
Combustion Chamber	TBD C2-02	Optics Bench	TBD C2-02
FOMA Control Unit	TBD C2-02	Optics Bench	TBD C2-02
PI Specific electronic Box	TBD C2-02	Optics Bench	TBD C2-02
IPP	TBD C2-02	Optics Bench	TBD C2-02

APPENDIX D CIR INTERNAL ELECTRICAL/DATA INTERFACES.

D.1 Scope.

This section gives the CIR internal electrical/data interfaces.

D.2 CIR internal electrical/data interfaces.

The CIR internal electrical/data interfaces are given in Table XXX. The detailed definitions are given in CIR-SPC-0115.

Table XXX. CIR internal electrical/data interfaces

Function	Start	Part #	Mate Part #	End	Part #	Mate Part #
ELEC. INTFC. FOR DIAGNOSTICS	JPIL1	DSXN3R-S106P-S106P-S55S-6301	"End" same as mate	PPIL1 ON CSAP	DSXN3P-S106S-S106S-S55P-6001	"Start" same as mate
ELEC. INTFC. FOR DIAGNOSTICS	JPIL2	DSXN1R-S26S-6301	"End" same as mate	PPIL2 ON CSAP	DSXN1P-S26P-6001	"Start" same as mate
ELEC. INTFC. FOR DIAGNOSTICS	JFCU1	DSXN3R-S106P-S106P-S33C4S-6301	"End" same as mate	PFCU1 ON FCU	DSXN3P-S106S-S106S-S33C4P-6001	"Start" same as mate
ELEC. INTFC. FOR DIAGNOSTICS	JFCU2	DSXN1R-S106P-6301	"End" same as mate	PFCU2 ON FCU	DSXN1P-S106S-6001	"Start" same as mate
ELEC. INTFC. FOR DIAGNOSTICS	JOPB14	DSXN2R-S26S-S26S-6301	"End" same as mate	POPB14 ON FPP	DSXN2P-S26P-S26P-6001	"Start" same as mate
22AWG PI config. to chamber	POPB5	D38999/26FH35PN	D38999/24FH35SN	PCTC1	D38999/26FH35SN	D38999/20FH35PN
20AWG PI config. to chamber	POPB6	D38999/26FH55PA	D38999/24FH55SA	PCTC2	D38999/26FH55SA	D38999/20FH55PA
16AWG Power & PI config. to chamber	POPB7	D38999/26FH21PB	D38999/24FH21SB	PCTC3	D38999/26FH21SB	D38999/20FH21PB
22AWG PI config. to chamber	POPB8	D38999/26FH35PC	D38999/24FH35SC	PCTC4	D38999/26FH35SC	D38999/20FH35PC
BENCH POWER 1	POPB1	D38999/26FH21SN	D38999/24FH21PN	PEPC12	D38999/26FG16PN	D38999/20FG16SN
				PEPC13	D38999/26FG16PN	D38999/20FG16SN
				PEPC20	D38999/26FG16PN	D38999/20FG16SN
				PEPC21	D38999/26FG16PN	D38999/20FG16SN
BENCH POWER 2	POPB2	D38999/26FH21SA	D38999/24FH21PA	PEPC14	D38999/26FG16PN	D38999/20FG16SN
				PEPC15	D38999/26FG16PN	D38999/20FG16SN
				PEPC16	D38999/26FG16PN	D38999/20FG16SN
				PEPC18	D38999/26FG16PN	D38999/20FG16SN
				PEPC19	D38999/26FG16PN	D38999/20FG16SN
IOP POWER	PEPC17	D38999/26FG16PN	D38999/20FG16SN	PIOP3	D38999/26FE8SN	D38999/24FE8PN
BENCH DATA	PIOP2	D38999/26FH35PN	D38999/24FH35SN	POPB3	D38999/26FH35PN	D38999/24FH35SN
MAIN POWER	J1	NATC07T25LN3PN	**NATC06G25LN3SN**	PEPC1	MS3459L28-22S	MS3452L28-22P
AUX POWER	J2	NATC07T25LN3PA	**NATC06G25LN3SA**	PEPC2	MS3459L28-22S	MS3452L28-22P
ESS	J6	D38999/24FA98SN	D38999/26FA98PN	PEPC7	D38999/26FC35PN	D38999/20FC35SN
HRDL/CVIT	PIOP6	D38999/26FB2PN	D38999/24FB2SN	J7	NATC07T13N4SN	**NATC06G13N4PN**
				J16	NATC07T15N97SB	**NATC06G15N97PB**
SSC DATA	PIOP5	D38999/26FC98PN	D38999/24FC98SN	J5	MS3474L14-12S	**MS3475L14-12P**

Function	Start	Part #	Mate Part #	End	Part #	Mate Part #
				J11	MS247468T11F35S	**MS27467T11F35P**
				J12	BJ-76	**PL75-47**
EEU CONTROL	PEEU4	D38999/26FC8SN	D38999/24FC8PN	PFAN1		
FDSS/ARIS POWER	PEPC3	D38999/26FG16PA	D38999/20FG16SA	**P1**	**NATC06G15N35SN**	**NATC07H15N35PN**
				P4	NATC06G15N19SN	**NATC07T15N19PN**
PI 120V	JTBD			PEPC4	D38999/26FG16PA	D38999/20FG16SA
VALVE 1	PWFV1-1	GFE	GFE	PWFC1-1	GFE	GFE
SENSOR 1	PWFS1-1	GFE	GFE	PWFC2-1	GFE	GFE
VALVE 2	PWFV1-2	GFE	GFE	PWFC1-2	GFE	GFE
SENSOR 2	PWFS1-1	GFE	GFE	PWFC 2-2	GFE	GFE
EEU POWER	PEPC22	D38999/26FG16PN	D38999/20FG16SN	PEEU3	D38999/26FC8PN	D38999/24FC8SN
				PWFC3-1	D38999/26FC98SN	D38999/24FC98PN
				PWFC3-2	D38999/26FC98SN	D38999/24FC98PN
EEU DATA	PEEU2	D38999/26FC35PA	D38999/24FC35SA	PFAN1		
				PWFC3-1	D38999/26FC98SN	D38999/24FC98PN
				PWFC3-2	D38999/26FC98SN	D38999/24FC98PN
FDS/MAINT.	J43	NAT07T13N35PA		P1	**NATC06G15N35SN**	**NATC07H15N35PN**
				PEEU1	D38999/26FC35PN	D38999/24FC35SN
				J44	D38999/24FA35SN	D38999/26FA35PN
STATION/EEU DATA	PIOP4	D38999/26FD35PN	D38999/24FD35SN	PEEU1	D38999/26FC35PN	D38999/24FC35SN
				P1	**NATC06G13N35SN**	**NATC07T13N35PN**
				PEPC5	**PL155-47**	BJ-154
				PEPC6	**PL155-47**	BJ-154
				J3	NATC07T15N35PN	**NATC06G15N35SN**
				J4	NATC07T15N35PA	**NATC06G15N35SA**
				J46	NATC07T11N35PA	**NATC06G11N35SA**
				J47	**NATC07T11N35PB**	**NATC06G11N35SB**
THERMISTORS	PEEU1	D38999/26FC35PN	D38999/24FC35SN	FAN IN	AD590	Device, no mate

Function	Start	Part #	Mate Part #	End	Part #	Mate Part #
				FAN OUT	AD590	Device, no mate
				H.EX. IN	AD590	Device, no mate
				H.EX. OUT	AD590	Device, no mate
				PRIM. WATER	AD590	Device, no mate
				SEC. WATER	AD590	Device, no mate
				STATION IN.	AD590	Device, no mate
				STATION OUT.	AD590	Device, no mate
CIR RTR IMAGE	J8	MTP-ADPT	MTP-012M-SM, MTFA-12SM5	PFPP13	MTP-012M-SM, MTFA-12SM5	MTP-ADPT
CIR/FIR RTR CAN, EtherNet, Sync, and Video	J9	MTP-ADPT	MTP-012M-MM, MTF-12MM7	PIOP7	MTP-012M-SM, MTFA-12SM5	MTP-ADPT
FIR RTR IMAGE	J10	Not Used in CIR				
120 TO PI	PI SPECIFIC AVIONICS			PTBD		
SSC POWER	P5	**MS3475L14-12P**	**MS3474L14-12S**	P?	**GFE**	**GFE**
SSC ETHERNET	P11	**MS27467T11F35P**	**MS27468T11F35S**	P?	**GFE**	**GFE**
SSC VIDEO	P12	**PL75-47**	**BJ-74**	P?	**GFE**	**GFE**
DEVICE ESS	EPCU SHUTOFF SWITCH			P6	**D38999/26FA98PN**	**D38999/24FA98SN**
SAMS	PIOP1	D38999/26FB35PN	D38999/24FB35SN	PSAM1		

APPENDIX E CIR INTERNAL GAS INTERFACES.

E.1 Scope.

This section gives the CIR internal gas interfaces.

E.2 CIR internal gas interfaces.

The CIR internal gas interfaces are given in Table XXXI.

Table XXXI. CIR internal gas interfaces

Connection From	Interface From Description	Connection To	Interface to Description	Exposed Fluid	Fluid Exposed to Temperature Range K (C)	Fluid Exposed to Pressure Range kPa (psia)
Chamber	½” Parker Ultra Seal Fitting: Male connector 8-8 QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Exhaust Manifold	½” Parker Ultra Seal Fitting: Male connector 8-8QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Chamber gas	288-318 (15-45)	0.00013-931 (.00002 to 135)
Exhaust Manifold	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Absorber Cartridge	¼” Preece Quick Disconnect: 942-042-F04VD, 941-042-F04VD	Chamber exhaust gas	288-318 (15-45)	0.00013-931 (.00002 to 135)
Absorber Cartridge	¼” Preece Quick Disconnect: 942-042-F04VD, 941-042-F04VD	Vent Manifold	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Scrubbed chamber exhaust gas, chamber gas	288-318 (15-45)	0.00013-931 (.00002 to 135)

Connection From	Interface From Description	Connection To	Interface to Description	Exposed Fluid	Fluid Exposed to Temperature Range K (C)	Fluid Exposed to Pressure Range kPa (psia)
Vent Manifold	½” Parker Ultra Seal Fitting: Male connector 8-8 QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Manual Vent	½” Parker Ultra Seal Fitting: Male connector 8-8 QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Chamber gas, exhaust from GCIP, and scrubbed chamber gas	288-318 (15-45)	0.00013-931 (.00002 to 135)
Manual Vent	½” Preece Quick Disconnect: 942-082-F08VD, 941-082-F08VD	GIS VES	½” Preece Quick Disconnect: 51194-103-1-08-1-V-W-08-1-GD; 51194-103-2-08-1-V-Y-08-1-GD	Chamber gas, exhaust from GCIP, and scrubbed chamber gas	288-318 (15-45)	0.00013-931 (.00002 to 135)
Exhaust Manifold	½” Parker Ultra Seal Fitting: Male connector 8-8QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Vent Manifold	½”Swagelok VCR Fitting: SS-8-VCR-1-01081; SS-8-VCR-2-GR; SS-6LV-8VCR-3S-8TB2, SS-8-VCR-1	Chamber gas and exhaust from GCIP	288-318 (15-45)	0.00013-931 (.00002 to 135)
Vent Manifold	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Pump	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Chamber gas, scrubbed chamber gas	288-318 (15-45)	0.00013-931 (.00002 to 135)

Connection From	Interface From Description	Connection To	Interface to Description	Exposed Fluid	Fluid Exposed to Temperature Range K (C)	Fluid Exposed to Pressure Range kPa (psia)
Pump	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Chamber	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Scrubbed chamber gas, chamber gas	288-318 (15-45)	0.00013-931 (.00002 to 135)
Chamber	½" Parker Ultra Seal Fitting: Male connector 8-8QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Manual Vent	½" Parker Ultra Seal Fitting: Male connector 8-8QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Chamber gas	288-318 (15-45)	0.00013-931 (.00002 to 135)
Fuel Supply Manifold	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Interface Resource Ring	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Fuel	288-318 (15-45)	0.00013-931 (.00002 to 135)
Diluent/ Premixed Gas Supply Manifold	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Static Mixer	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Diluent/ Premixed gas	288-318 (15-45)	0.00013-931 (.00002 to 135)

Connection From	Interface From Description	Connection To	Interface to Description	Exposed Fluid	Fluid Exposed to Temperature Range K (C)	Fluid Exposed to Pressure Range kPa (psia)
High Percentage Oxygen Supply Manifold	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Static Mixer	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	High Percentage Oxygen, diluent	288-318 (15-45)	0.00013-931 (.00002 to 135)
ISS Nitrogen/ High Pressure Manifold	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Static Mixer	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Nitrogen, diluent, blend with oxygen up to 30%	288-318 (15-45)	0.00013-931 (.00002 to 135)
Static Mixer	½” Parker Ultra Seal Fitting: Male connector 8-8QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Interface Resource Ring	½” Parker Ultra Seal Fitting: Male connector 8-8QHAO-SS Gasket 8 QO-SS Gland 8-8 Q1M-SS + Nut 8BQ-SS	Mixed gas (nitrogen, diluent/ premixed gas and or oxygen)	288-318 (15-45)	0.00013-931 (.00002 to 135)
ISS Nitrogen/ High Pressure Supply Manifold	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Interface Resource Ring	¼” Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Nitrogen	288-318 (15-45)	0.00013-931 (.00002 to 135)

Connection From	Interface From Description	Connection To	Interface to Description	Exposed Fluid	Fluid Exposed to Temperature Range K (C)	Fluid Exposed to Pressure Range kPa (psia)
Interface Resource Ring	1/8" Swagelok Fitting SS-200-6-1LV	GC Instrumentation Package	¼" Parker Ultra Seal Fitting: Male connector 4-4 WBQ-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Chamber gas	288-318 (15-45)	0.00013-931 (.00002 to 135)
GC Instrumentation Package	¼" Parker Ultra Seal Fitting: Male connector 4-4 WBQ-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Exhaust Manifold	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Chamber gas, check gas, argon and helium	288-318 (15-45)	0.00013-931 (.00002 to 135)
Check Gas	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	GC Instrumentation Package	¼" Parker Ultra Seal Fitting: Male connector 4-4 WBQ-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Check gas (specific to each PI)	288-318 (15-45)	0.00013-552 (.00002 to 80)
Argon	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	GC Instrumentation Package	¼" Parker Ultra Seal Fitting: Male connector 4-4 WBQ-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Argon	288-318 (15-45)	.00013-690 (.00002-100)

Connection From	Interface From Description	Connection To	Interface to Description	Exposed Fluid	Fluid Exposed to Temperature Range K (C)	Fluid Exposed to Pressure Range kPa (psia)
Helium	¼" Parker Ultra Seal Fitting: Male connector 4-4 QHAO-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	GC Instrumentation Package	¼" Parker Ultra Seal Fitting: Male connector 4-4 WBQ-SS Gasket 4 QO-SS Gland 4-4 Q1M-SS + Nut 4BQ-SS	Helium	288-318 (15-45)	.00013-690 (.00002-100)

APPENDIX F CIR INTERNAL ENVIRONMENTAL CONTROL SYSTEM INTERFACES

F.1 Scope.

This section gives the CIR internal environmental control system interfaces.

F.2 CIR internal environmental control system interfaces.

The CIR internal environmental control system interfaces are given in Table XXXII. The detailed definitions are given in CIR-SPC-0115.

Table XXXII. CIR internal environmental control system interfaces

Interface	Connection	Fluid	Fluid Exposed to Temperature Range K (C)	Fluid Exposed to Pressure Range kPa (psia)
WTCS to EPCU	Self-Sealing Fluid QD's, Power, 51313-1-06-V-#2-08-GD (inlet); 51313-1-06-1-V-#2-08-GY (Outlet)	Cool Water	289.1 – 321.9 (16.1 – 48.9)	101.3 – 834 (14.7 – 121)
WTCS to ATCU	Self-Sealing Fluid QD's, 51313-3-08-1-V-#5-06-P (Inlet); 51313-1-08-1-V-#1-08-GD(Outlet)	Cool Water	289.1– 321.9 (16.1 – 48.9)	101.3 – 834 (14.7 – 121)
WTCS to ARIS Coldplate	Self-Sealing Fluid QD's, 51313-1-08-1-V-#1-08B (Inlet); 51313-3-08-1-V-G-08-1-B (Outlet)	Cool Water	289.1 – 321.9 (16.1 – 48.9)	101.3 – 834 (14.7 – 121)
WTCS to Science	Self-Sealing QD's, 51313-1-06-1-V-#1-06-B (Inlet); 51313-1-06-1-V-#1-06-P (Outlet)	Cool Water	289.1 – 321.9 (16.1 – 48.9)	101.3 – 834 (14.7 – 121)
GN2 to Nitrogen Manifold	Self-Sealing QD's, 942-062-F-06-VD, 941-062-F-06-VD	Nitrogen	288 – 318 (15 – 45)	0.00013 – 931 (.00002 to 135)
Manual Vent Valve Manifold to VES	Self-Sealing QD's, 941-08-082-F-08-VD, 942-08-082-F-08-VD	Waste Gas	288 – 318 (15 – 45)	0.00013 – 931 (.00002 to 135)

APPENDIX G EXCEPTIONS

G.1 Scope.

This appendix documents the exceptions to this document.

G.2 3.2.4.1 CIR maintenance access exception.

The CIR shall be designed to allow for the replacement of assemblies and components and the performance of other maintenance activities without rotating the CIR from its installed position within the US Lab.

G.2.1 Exceptions to CIR maintenance access.

a. The CIR design requires rack rotation for ARIS maintenance activities.
b. The CIR design requires rack rotation for EPCU maintenance activities.

G.2.2 Rationales for exceptions to CIR maintenance access.

a. In order to minimize the impact to useable volume within the CIR, ARIS components are located in places not easily accessible when the CIR is in its on orbit configuration to meet its design requirements. A severe cost and science impact would be incurred to redesign the CIR to meet this requirement for ARIS.
b. The EPCU design would require modifications to its mounting equipment and umbilical design to meet the CIR maintenance requirement. The CIR would only need to be rotated from its installed position in the event of an off-nominal maintenance activity or replacement of the EPCU.

G.3 3.2.2.1.2 CIR on orbit envelope.

The CIR, with applicable PI hardware, shall have an on orbit envelope as specified in SSP 41017 Part1, paragraph 3.2.1.1.2 and shall follow the on orbit payload protrusion requirements as specified in SSP 57000, paragraph 3.1.1.7.

G.3.1 Exceptions to CIR on orbit envelope.

a. Exception to the on orbit temporary protrusions as specified in SSP 57000 to allow the CIR Optic Bench to protrude into the aisle for maintenance activities.
b. Exception to the on orbit temporary protrusions as specified in SSP 57000 to allow the CIR doors to protrude beyond the specified envelope for maintenance activities.

G.3.2 Rationales for exceptions to CIR on orbit envelope.

a. The CIR Optic Bench design minimizes crew resources and saves space by providing an alternative to rotating the rack for reconfiguration. The Optic Bench provides structural support, electrical connections, and mounting connections for all science support hardware. The Optic Bench will only be deployed while crew attended, meets human interface requirements for interfaces and operation as specified in SSP 57000, and allows for rapid reconfiguration of hardware for increased science throughput. The design allows the Optic Bench to be quickly restowed and does not interfere with egress requirements. This exception has been approved by the ISS Payload Office under PIRN No. SSP 57217-NA-0001A.

b. The CIR door design does not interfere with the volumes for access and egress. The door sweep does not extend beyond the protrusion violation in the Optic Bench. The doors will only be open to perform maintenance and science activities on the CIR. This exception has been approved by the ISS payload Office under PIRN No. SSP 57217-NA-0003.

G.4 3.2.2.2 b. CIR weight characteristics.

The CIR, with applicable PI hardware, shall not exceed an on orbit mass of 804.2 kg (1773 lbs), excluding stowage hardware.

G.4.1 Exception to CIR weight characteristics.

Exception to the on orbit mass requirement of 804.2 kg (1773 lbs) to 1100 kg (2424.4 lbs) is required.

G.4.2 Rationale for exception to CIR weight characteristics.

Due to the extensive science requirements imposed on the CIR, a mass increase to 1100 kg (2424.4 lbs) is required to meet the science requirements. Analysis to reduce the mass has shown detrimental science reductions in the loss of cameras, observation ports, and support equipment. More crew and stowage resources would be required to perform the experiments. This exception has been approved by the ISS payload Office under PIRN No. SSP 57217-NA-0002.

G.5 3.2.1.23.6a. Mid IR imaging spectral range.

The mid IR imaging capability shall have a spectral range from 1000 to5000 nm.

G.5.1 Exception to mid IR imaging spectral range.

Exception to the mid IR spectral range from 1000 nm to 5000nm to 3000 nm to 5000nm is required.

G.5.2 Rationale for exception to mid IR imaging spectral range.

The present specified range (1000-5000 nm) can be met by removal of the 3000 nm cut-off filter typically installed in this type of camera using PtSi sensor technology. However, higher sensitivity and improved signal to noise performance would be obtained with InSb sensor technology; but this technology may not provide usable sensitivity down to 1000 nm Therefore, it is recommended that the specification on spectral range be narrowed to 3000-5000 nm which could be met with InSb sensor technology and provide more optimum performance from a sensitivity standpoint for science.

This recommendation is consistent with the camera studies recently conducted by Phoenix. More than 80% of the science requirements levied in the mid-IR are met with the narrower spectral band. SNR (which is not specified) is enhanced substantially by the recommendation. Interfaces are provided which permit a specialized sensor for the 1000-3000 nm region to be PI developed and installed if ever needed.

G.6 3.2.2.3b. CIR power.

The CIR, with applicable PI hardware, when integrated into the FCF, shall not exceed a power draw of 2,000 W.

G.6.1 Exception to CIR power.

Exception from the 2,000W power draw to 6,000 power draw is required.

G.6.2 Rational for exception to CIR power.

Based on extensive analysis of the basis experiments' power requirements and the minimum power required to operate the CIR, the maximum power draw needed to for the CIR to perform its mission is 6,000 W.

APPENDIX H TBD'S

H.1 Scope.

This appendix lists all items in this document that need to be determined (TBD).

H.2 List of TBD's.

Table XXXIII lists all the TBD's in this document.

Table XXXIII. TBD's

TBD Number	Description	Document Paragraph
03-01	SAMS data interface requirement	3.1.5.4
03-02	The oxidizer replenishment rate has not been quantified.	3.2.1.21
03-03	SAMS data interface requirement	3.2.2.9.7
03-04	Number of on-orbit MMCH/Y for scheduled and unscheduled maintenance activities	3.2.4
04-01	The oxidizer replenishment rate has not been quantified.	4.2.1.21
04-02	SAMS data interface verification	4.2.2.9.7
04-03	Number of on-orbit MMCH/Y for scheduled and unscheduled maintenance activities	4.2.4
04-04	Number of Table that shows hand dimensions for sufficient grasp capability for the 5th percentile female and 95th percentile male	4.3.7.17.1
C2-01	Structural interfaces not yet finalized	C.2.1
C2-02	Structural interfaces not yet finalized	C.2.2